Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JANUARY 1950

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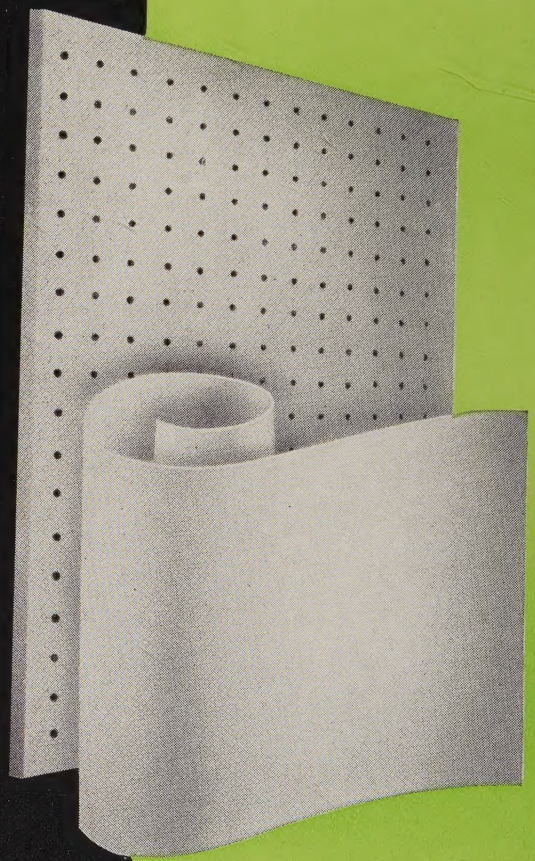

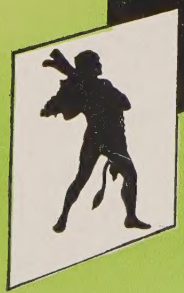

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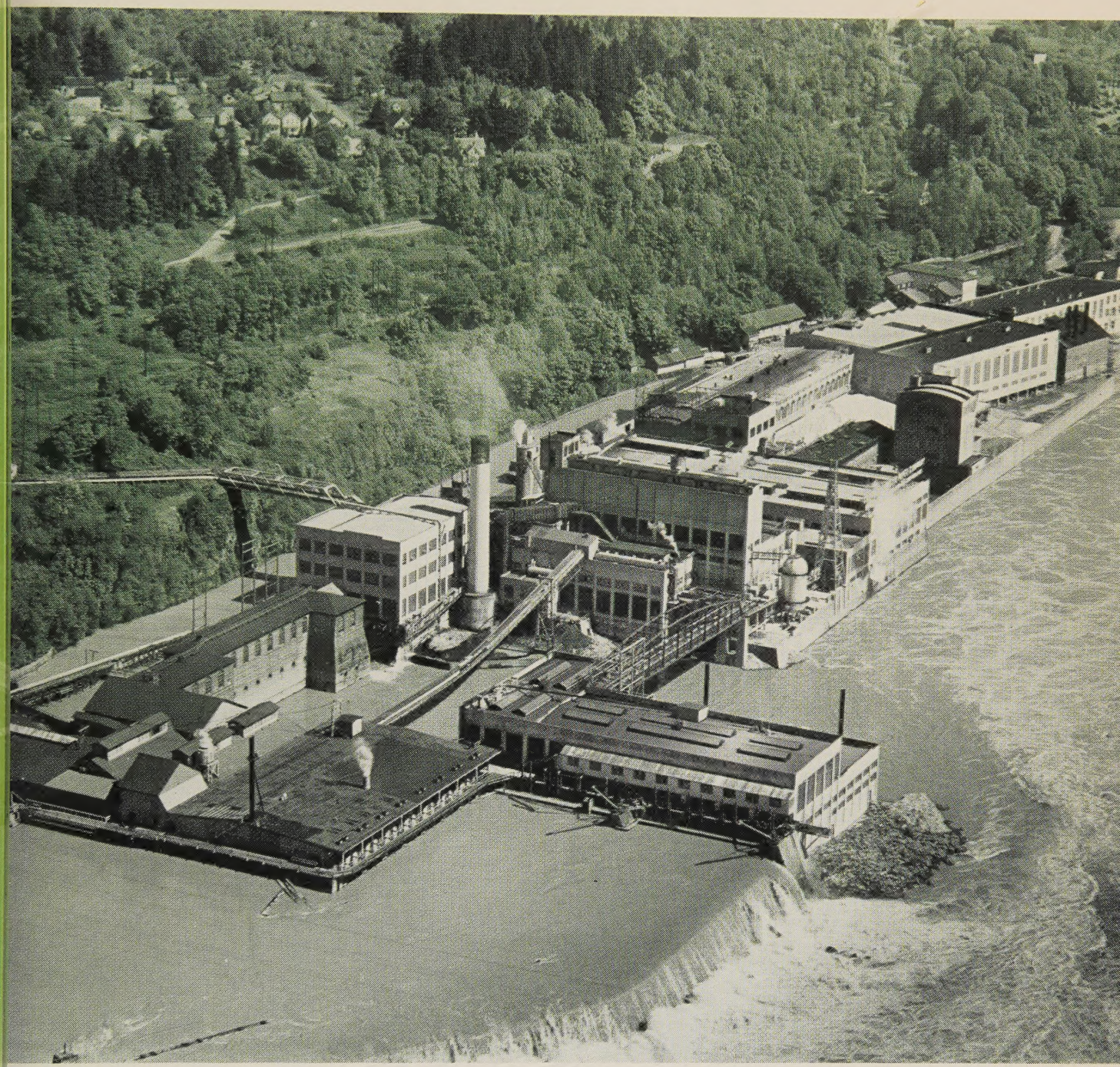

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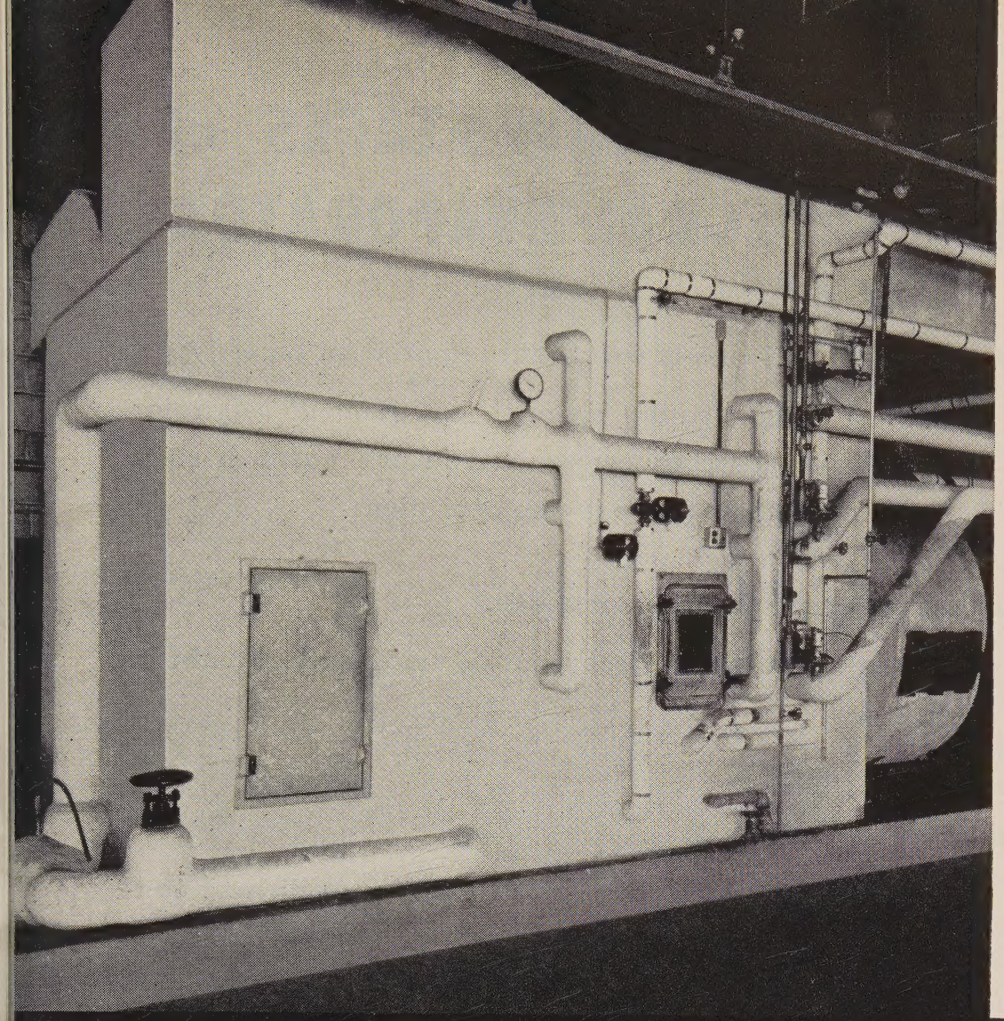

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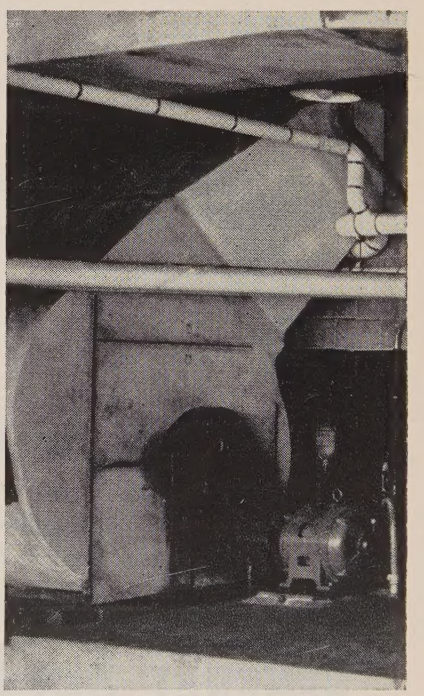

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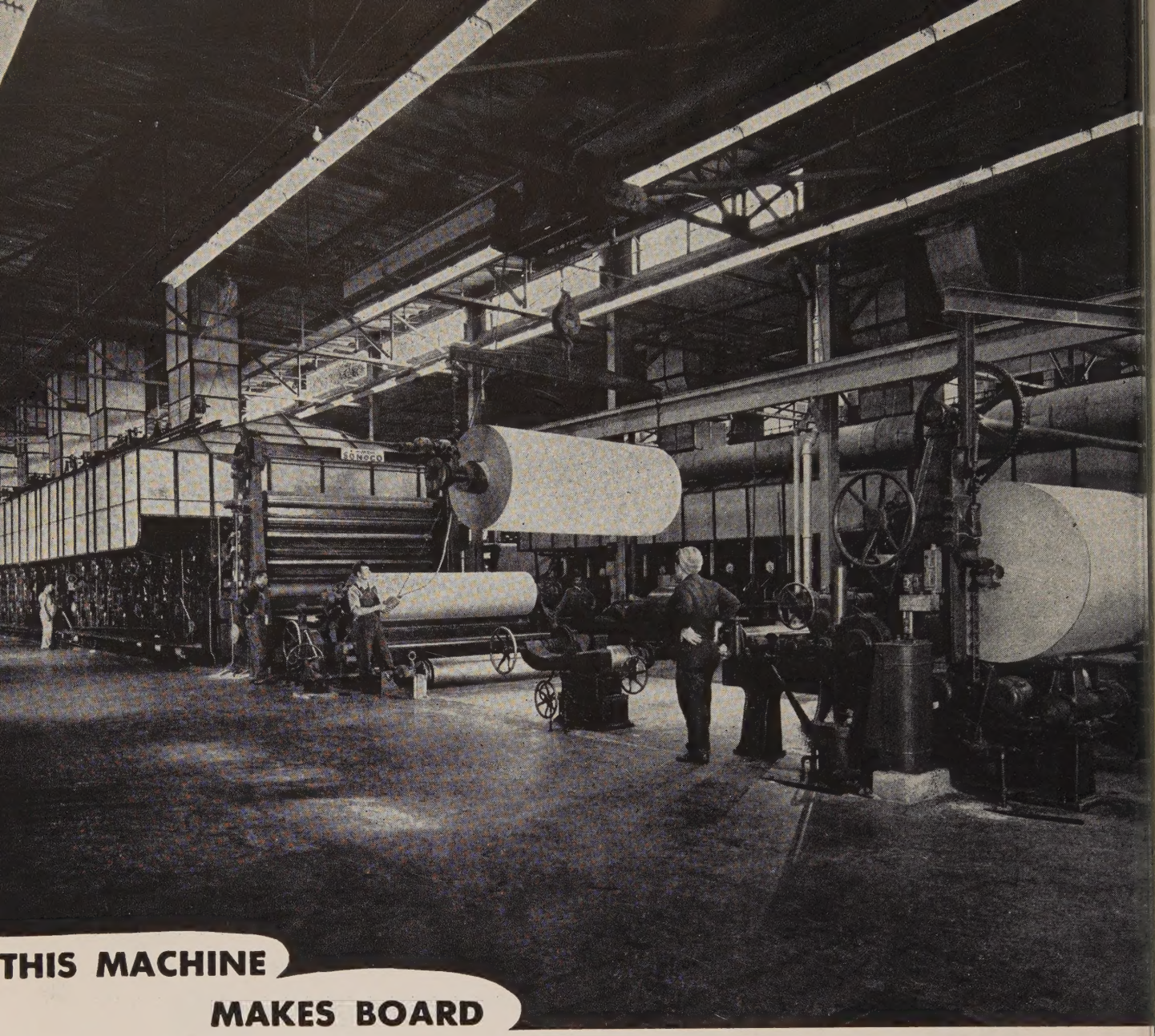

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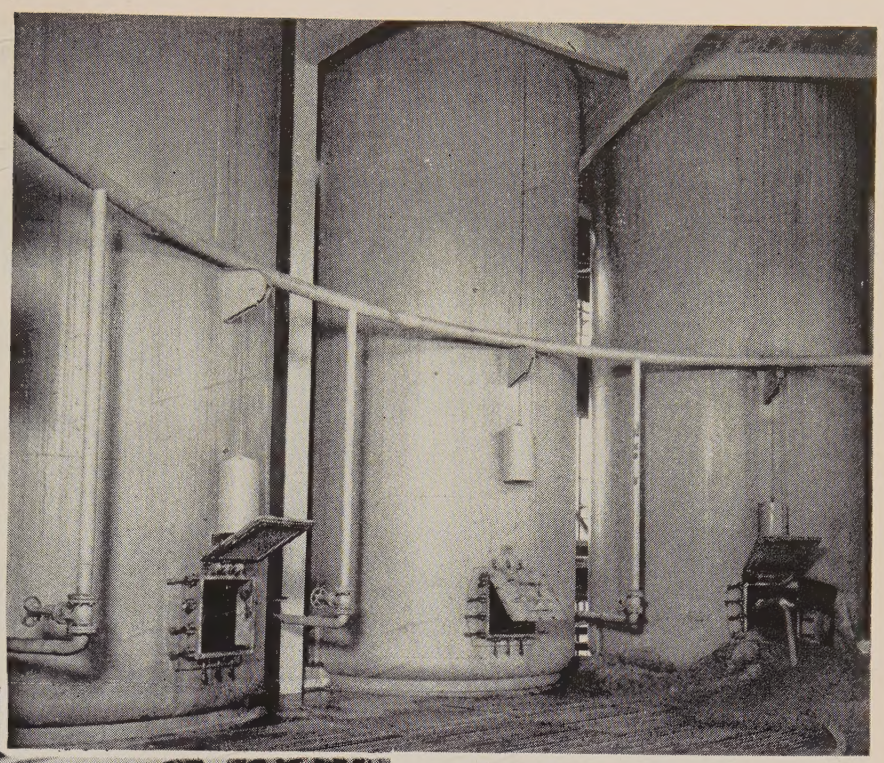
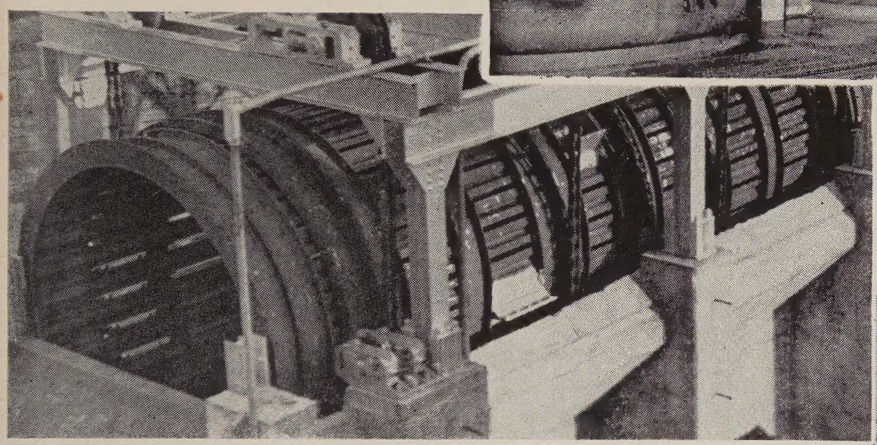
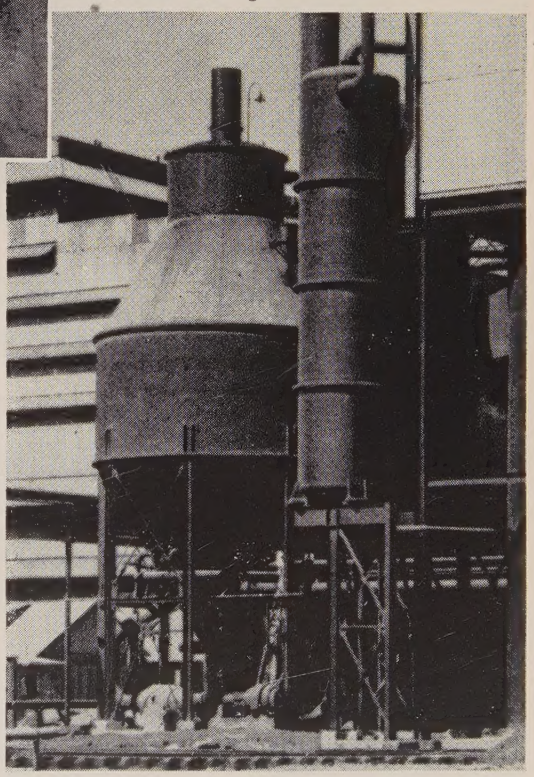




Above: 14 ft. 6 in. diam. by 33 ft. 4 in. diffusers built for the Container Corp. of America, Fernandina, Florida.

At left: Barking Drum built for the Fibre Making Processes Inc. at the Chesapeake-Camp Corp. mill, Franklin, Virginia.

Below: 26-ft. diam. by 13-ft. elevated blow tank built for the Union Bag and Paper Corporation, Savannah, Georgia.



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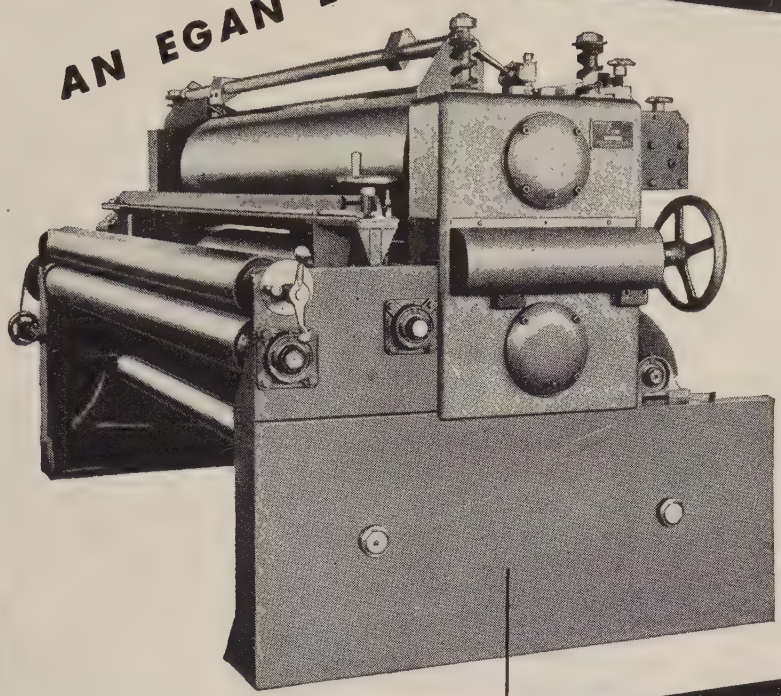

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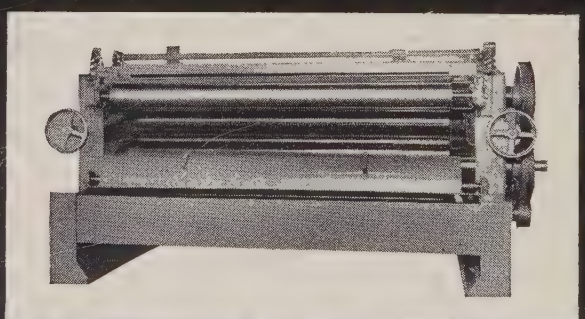

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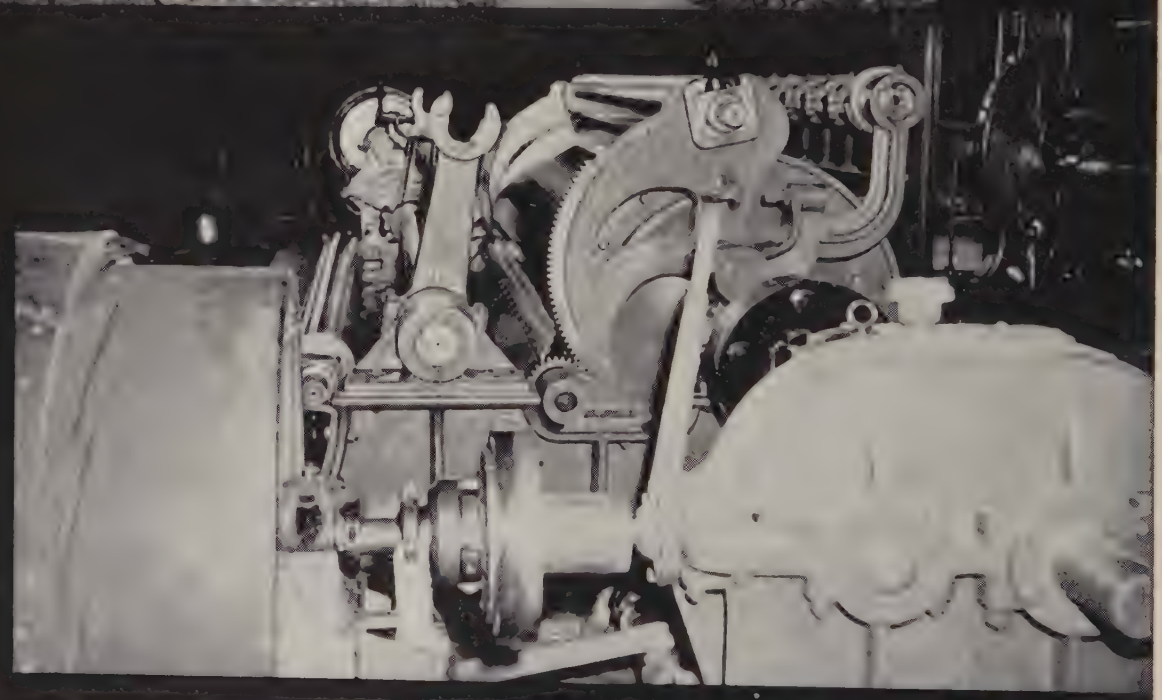

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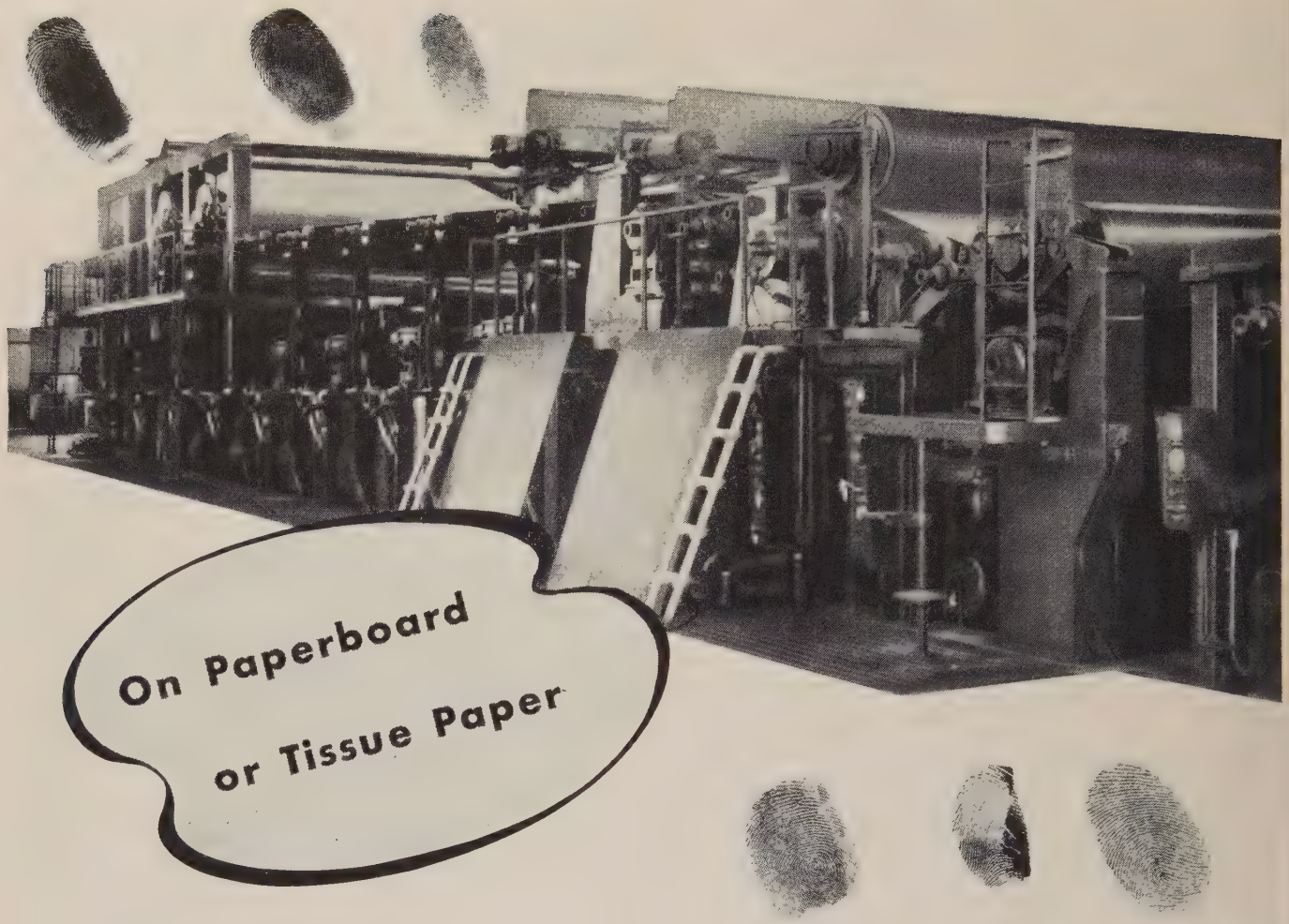

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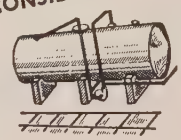
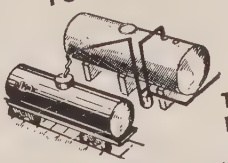


Tank Storage at the mill



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Supply-Demand Data on Chief Nonfibrous Raw Materials Used in the Pulp and Paper Industry

III. Organic Papermaking Chemicals

RUTH E. SHALLCROSS

Sources of information about raw materials are almost as important as the materials themselves when they become scarce. As chemical markets reflect depletion of natural resources, information about them takes on increasing importance. With the realization that accurate demand-supply information is important for many paper chemical raw materials, enough demand will be generated to see that it is forthcoming. Thus far, the demand has not been sufficiently great to guarantee adequate statistical data on many of these materials. Articles appear from time to time in various journals showing the amount of chemicals used in the pulp and paper industry. Frequently data are given for no particular period on the apparent assumption that they will be applicable for any period. But the paper industry is far from static and its use of any chemical varies decidedly from year to year; for that very reason, it is imperative that collected data should be continuous so that trends can be established. At the present time there is perhaps no information concerning the paper industry more difficult to find, or more carelessly handled, than the consumption data on pulp and papermaking chemicals.

This is the third and last of a series of articles on this subject designed primarily to bring together in one place what is known and to point out what is merely estimated about the consumption patterns of the chief pulp and papermaking nonfibrous raw materials. The first article was on the pulpmaking chemical raw materials (*Tappi* 32, no. 11) and the second on the inorganic papermaking chemicals (*Tappi* 32, no. 12). This discussion concerns the organic papermaking chemical materials. The chief ones are the coating and sizing agents: rosin, glue, starch, casein, and waxes. Other organic raw materials include the resins and glycerin. There are a large group of organic materials which are used in too small amounts to make them significant and about which, as yet, we have no consumption data.

ROSIN

Rosin thus far has been the principal agent for engine sizing of paper and, therefore, the best medium as yet developed for imparting moisture resistance to paper. Rosin is used in nearly all papers, although a few, such as absorbent, parchment, sanitary, and tissue papers, do not use it. Some papers, such as newsprint, contain rosin only in very small amounts, whereas others, such as the bond writing papers, contain a considerable amount of it.

Ruth E. Shallcross, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

More data exist on rosin than on most other nonfibrous organic raw materials used by the paper industry. The Naval Stores Research Division of the Department of Agriculture exists primarily to collect, analyze, and report annually the production, distribution, consumption, imports and exports, and stocks of both turpentine and rosin. Some who are close to the supply and sales of rosin size are of the opinion, however, that the Division's data on the use of rosin by the paper industry is probably too low—perhaps by as much as 15%, although there is no way to check this accurately. For want of a complete check and in order to obtain comparability of secular data, the Department of Agriculture reports must be used. These reports show the industrial consumption including the amounts of rosin that are consumed by paper companies both as rosin and as size purchased from the chemical industry. The rosin used by the chemical industry for paper size is tabulated under "paper and paper size." Future rough estimates of rosin requirements have sometimes been made by taking estimated paper and paperboard production and multiplying by the factor 0.005. However, this factor, when applied to past production data, will give higher consumption figures than those reported by the government. The estimating factor, it is thought, offsets those papers which contain 3 to 4% of rosin by the papers that contain no

Table I. Rosin

Unit: 1000 tons of net rosin

Crop years	*Total industrial consumption*	*Consumption by paper industry 1000 tons, %*	
1927–1928	190	62.5	32.9
1928–1929	194	70.1	36.1
1929–1930	232	81.5	35.1
1930–1931	191	71.7	37.5
1931–1932	167	63.0	37.8
1932–1933	150	54.8	36.5
1933–1934	177	67.4	38.0
1934–1935	186	70.8	38.0
1935–1936	216	75.0	34.7
1936–1937	256	86.3	33.7
1937–1938	232	71.4	30.8
1938–1939	216	66.8	30.9
1939–1940	248	74.7	30.1
1940–1941	227	68.9	30.3
1941–1942	344	93.2	27.1
1942–1943	296	77.0	26.0
1943–1944	341	99.3	29.1
1944–1945	400	98.5	24.6
1945–1946	317	71.2	22.5
1946–1947	353	88.9	25.2
1947–1948	346.5	90.3	26.0
1948–1949	323	92.3	28.6

Source: Adapted from the yearly Naval Stores Reports, U. S. Department of Agriculture, 1927–1928 through 1947–1948.

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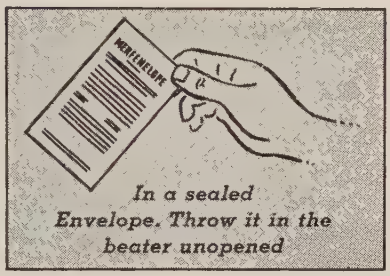

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rosin at all. But future requirements may be altered by new competing, sizing materials.

The naval stores reports were formerly given in units of drums of 500 pounds gross weight (420 pounds net). Since 1943, the reports have been given in drums of 520 pounds net weight. To convert rosin to rosin size, according to some of the suppliers, a rough approximation may be obtained by multiplying pounds of rosin by 1.06 to obtain dry rosin size. Or, if one wishes to get an approximation of 70% rosin size, the total amount of rosin should be divided by 0.66. The amount of rosin used by the paper industry, as reported in the naval stores reports is indicated in Table I (the figures include both gum and wood rosin).

For over 20 years the paper industry has been the chief consumer of rosin, with some few exceptional years when another industry either tied with the paper industry or used a little more rosin. Up to the beginning of the forties, the two chief consumers of rosin were the paper and soap industries; however, in the early forties, the ester gum and synthetic resins industry took second place. The paint and varnish industry at one time was an important consumer of rosin but today it ranks fifth in the consumption pattern. In 1946–1947, the chemical industry (when pharmaceuticals are included) consumed a little more rosin than the paper industry. Whether it will continue to challenge the paper industry for first place remains to be seen. The relative positions of the major industries are shown percentagewise in Table II.

For many years rosin was a waste product in the production of turpentine, tar, and pitch. For every barrel of turpentine produced, three barrels of rosin had to be dumped into nearby streams or lakes, an economic waste that was not eliminated until after 1807, when Illig discovered that rosin soap was an excellent sizing and waterproofing agent for paper. Before the first World War, the principal source of rosin was from the distillation of gum turpentine. So scarce had this material become that it was mined where it had been dumped years before. During the period of 1910 to 1915 the method of extracting rosin from waste pinewood, which had been developed by Yaryan in 1909, was gradually put into commercial operation. From then on, rosin from this source grew in importance until, in 1945–1946 for the first time, a little more wood rosin was produced and consumed than gum rosin as is shown in Table III.

No wood rosin is imported but both wood and gum rosin are exported. The foreign demands have grown recently, although they still are not as high as in 1935–1936, when 50% of the domestic production was exported. Rosin is shipped to Europe, South America, and Cuba, and some is exported to the Orient and Australia. The production in such countries as Russia, France, Spain, Portugal, and Greece increased before the war which lowered their need for imports. No postwar data are available from these countries.

Paper producers buy rosin as such or as rosin size from the chemical companies. It is usually purchased in tank cars with about 70% solids content. The tendency has been for more of the mills to buy their size rather than to make it themselves even though, from a cost analysis, the advantages would seem to be in favor of making the size. Loddengaard (*22*) asked some mill superintendents in 1940 how they justified the freight costs on water in size and advised them to "make your own size and save the service charges. They are too high." But economies in a mill are not always figured on a strictly cost basis. The cost of steam, labor, and raw rosin (even when purchased at a higher rate than the chemical companies have to pay), when compared with the price of the size, may show a lower cost when produced at a given mill, but a detailed economic analysis will reveal that other factors are important which would not be apparent in the basic cost analysis. Subjective factors are as important economically in determining action as objective ones and engineers or cost accountants sometimes neglect them. A small mill may use very little rosin size a day. If it were made incorrectly, considerable trouble could be caused in the paper mill, and expensive paper ruined.

Table II. Rosin Consumption by Industrial Usage

Crop years	*Paper, %*	*Chemicals and pharmaceuticals, %*	*Soap, %*	*Ester gum and synthetic Resins, %*	*Paint and varnish, %*	*Other, %*
1932–1933	36.5	0.4	36.5	[a]	17.0	9.6
1934–1935	38.0	0.4	32.0	[a]	20.0	9.6
1936–1937	33.7	9.7[b]	24.4	8.4	11.5	12.3
1938–1939	30.9	12.0	23.0	10.6	12.7	10.8
1940–1941	30.3	10.7	17.7	11.8	14.6	14.9
1942–1943	26.0	18.3	16.9	13.1	11.6	14.1
1944–1945	24.6	17.0	21.0	16.2	8.6	12.6
1946–1947	25.2	25.4	11.3	19.9	8.3	9.9
1947–1948	26.0	26.3	10.8	19.3	8.4	9.2
1948–1949	28.6	27.8	7.6	17.1	8.9	10.0

SOURCE: Naval Stores Reports, U. S. Department of Agriculture.
[a] No data.
[b] Includes rosin consumed in producers' plants for the first time.

Table III. Production of Gum and Wood Rosin

Unit. Thousands of Drums of 520 Pounds Net

	1947–1948 Crop year			*1946–1947 Crop year*			*1945–1946 Crop year*		
	Gum	*Wood*	*Total*	*Gum*	*Wood*	*Total*	*Gum*	*Wood*	*Total*
Product	828	1163	1991	753	968	1720	694	758	1452
Approximate U. S. consumption	498	846	1344	542	830	1372	627	640	1267

SOURCE: Naval Stores Reports for 1945–1948.

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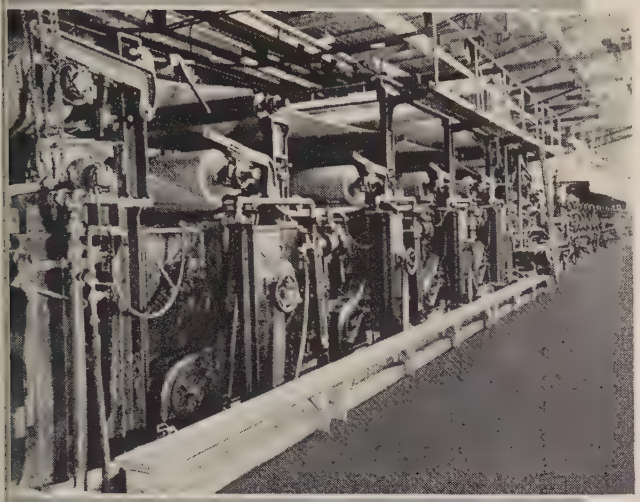

Original installation of Stream-Flow Vat Systems. Started up January 1940 on tags and other high-grade boards.

Close-up of smooth inlet flow produced by Flow Spreaders in basement—another early installation, on high grade light weight cylinder papers.

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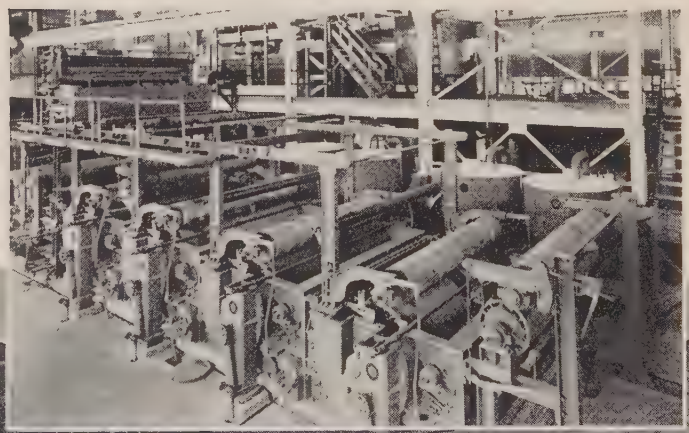

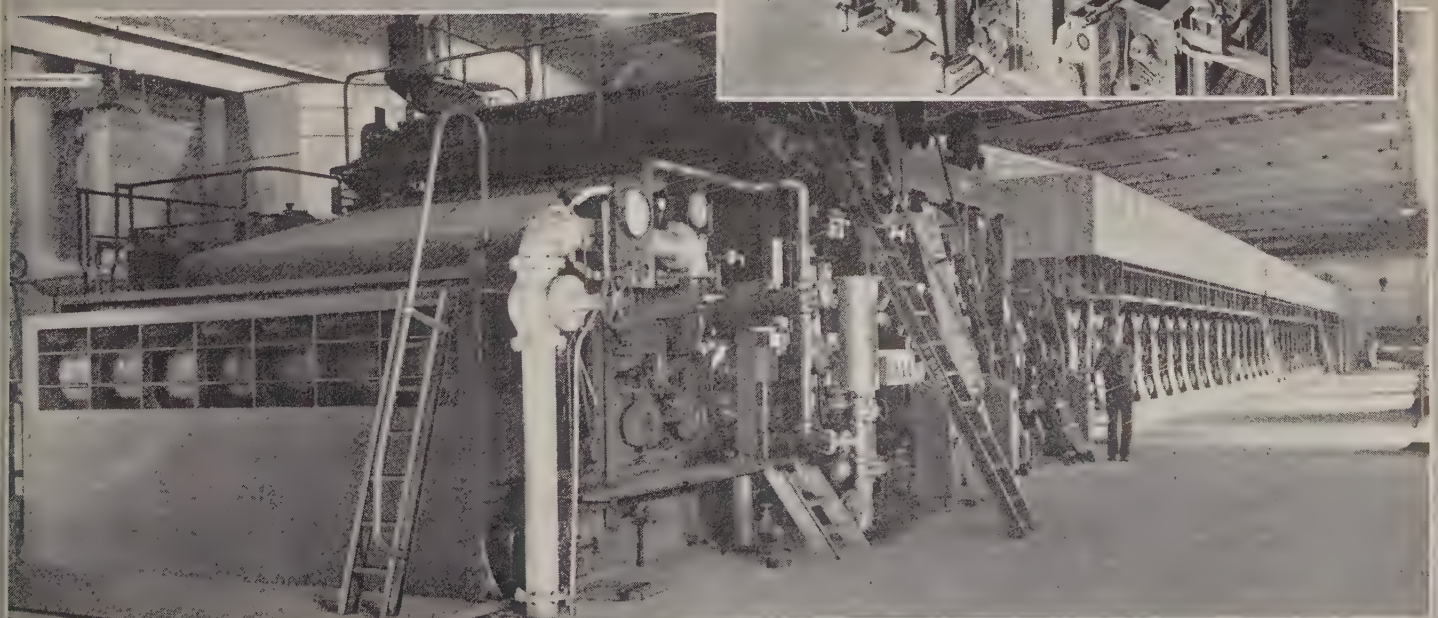

One of three Stream-Flow roofing installations, this one on the most modern felt machine ever built. Making floor felt.

The determining factor in a company's decision to buy its size is frequently the cost of the paper wasted if the size is not right for the purposes needed. It has been estimated that, at present, perhaps 95% of all paper mills use purchased rosin size rather than make their own, undoubtedly principally because of the nuisance value of making it of uniform consistency and because of great danger of paper loss.

Within the last two decades, less rosin has been used in printing papers because an increase in tub sizing has resulted in less beater sizing and because other ingredients besides rosin have been used. Prosize is a prewar developed form of rosin size which is usually prepared at the consuming paper mills from gum rosin, alpha protein from soybeans, and borax. It is particularly advantageous in the manufacture of fine papers. It is estimated that it is used for this purpose at the rate of about 600 tons per month. The total amount of rosin used as Prosize has been estimated by a supplier to be approximately 500 tons per month. In the field of engine sizing, rosin has practically no competitor, although it is true that some wax sizes are used and some endeavor is being made to utilize the petroleum resins. Whether or not these petroleum resins will capture the market for papers where color is not a disadvantage will depend upon technical advances in the sizings and the petroleum industry's ability to lower costs. Much has already been done in the laboratory to make them a success.

Wood rosin prices are a little lower than those for gum rosin, although prices for the highest grades of both are about the same. The weighted seasonal average price per 100 pounds of gum rosin reported by the Department of Agriculture shows the following changes since 1931.

1930–1931	$2.18
1934–1935	1.98
1941–1942	2.69
1945–1946	6.45
1947–1948	7.83

SOURCE: (*35*) annual report for 1946–1947:12, and annual report for 1947–1948:7.

The pre-1941 prices, which were quoted in barrels, were converted by the Department of Agriculture to 100 pound net weight. Rosin became scarce only in the last year of the war; but, by restricting exports, the domestic consumption was maintained although sometimes at the expense of the grade desired. The Department of Agriculture lists 13 grades of gum rosin, most of which can be used as a size in some types of paper. The grades most commonly used are in the medium price range. The competitors of rosin size must prove that they can make a better product at a price not only lower than the price of rosin today but at least as low as the depressed price before the war or it will not seriously challenge the rosin market. Since some of the chemical companies own their own sources of rosin, they can allow the price to fall to very low levels before they would be forced to discontinue the manufacture of size.

STARCH

In the paper industry, starch is used for beater and tub sizing, as a coating adhesive, as a laminating agent for paper and paperboard, and in the manufacture of corrugated boxes. Starch helps bind the cellulose fibers together. It also aids in the retention of the mineral fillers and pigments, such as the clays and titanium dioxide.

The paper industry can use various types of starch—corn, tapioca, potato, sago, and wheat. Corn starch constituted 73% of the total starch used by paper manufacturers in 1933, but in 1937 the amount of tapioca starch used (over 90% of which was imported from Java) was greater than corn as Table IV indicates.

No data exist to show accurately the consumption of each type of starch in the postwar years, but corn starch is the main type used at the present time. It has been estimated by a well-known supplier of various starches to the paper industry that, in 1946–1947, corn starch made up 85% of all the starch used, although imports of tapioca were still small from the Netherlands East Indies; Brazilian tapioca was also scarce.

When both tapioca and cornstarch have been available, the past usage trend has favored tapioca. During the thirties, the consumption of cornstarch remained about the same, whereas the consumption of tapioca increased to keep pace with the growing paper industry. Some companies claim that, technically, tapioca is preferable when the two types of starch are available at approximately the same price. Of course, when the price of tapioca (especially the medium grade) fell considerably below the price of corn starch, the mills preferred tapioca. Imported tapioca from the Dutch East Indies came in duty free after 1931 and the average prices for medium grades (f.o.b. consumers' plants) was 3.19 cents per pound for corn starch as compared with 3.05 cents for tapioca. Corn starch sold for 4.14 cents in 1935 and tapioca for 3.12 cents.

When the war shut off the imports of tapioca from the East Indies, the industry was forced to use other starches. This led to considerable research directed toward overcoming the technical superiority of tapioca over corn starch for both beater and surface sizing. Because of this research, it seems highly probable that cornstarch will maintain its superiority over all other forms of starch when competition again develops between them unless, of course, corn starch is abnormally high priced as compared with the other starches.

Table IV. Consumption of Domestic and Imported Starches
(Thousands of Pounds)

Year	Domestic starches				Imported starches					Total all starches
	Corn	Potato	Total	%[a]	Tapioca	Sago	Potato	Total	%[a]	
1933	81,315	1	81,316	72.9	29,457	730	27	30,214	27.1	111,530
1935	70,230	105	70,335	65.9	35,246	1,115	17	36,378	34.1	106,713
1936	97,680	310	97,990	61.5	59,375	1,938	19	61,336	38.5	159,326
1937	89,243	311	89,554	46.2	102,568	1,565	24	104,157	53.8	193,711

[a] Percentage of all starches consumed.
SOURCE: (*44*) Tables 70 and 72, pp. 124 and 126.

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The other types of starch besides corn and tapioca do not compete volumewise. Potato starch was used much more extensively during the last war. Barnett (*5*) states that the paper industry has used 10,000,000 pounds for years. Inasmuch as the industry used only 335,000 pounds in 1937, the increase to 10,000,000 pounds must have taken place during the war years. Barnett estimates that another 10,000,000 pounds will be consumed this year in the usual sizing and coating operations; in addition, he estimates that 1,500,000 pounds will be employed in a patented precipitation process. He further estimates the total U. S. consumption of potato starch is now approximately 58,000,000 pounds. These figures would indicate that the paper industry now consumes about 20% of the total potato starch consumption. This is in contrast with the 1% consumed by the industry in 1937.

Potato starch converts easily with enzymes but ordinarily cannot be placed consistently on the market as cheaply as cornstarch and varies too much in quality to be used extensively. For paper mills in the neighborhood of the Maine potato starch mills, the low freight rates make potato starch attractive which accounts for its continued use in that region. With the present dip in both potato and cornstarch prices, the quoted prices of the two types of starch are close enough to make freight the determining factor (*29*). With a continued government support program, potato starch is likely to be produced in quantity and competition may improve the quality enough to seriously challenge cornstarch for the paper market.

Wheat starch is used by the paper industry only when corn starch is especially scarce and selling at an abnormally high price. The wheat starch manufacturers have much higher costs than corn starch producers because wheat, over a period of years, has sold on the average at a much higher price than corn. In the paper industry, this higher cost for wheat starch has not been justified on the basis of any superior value which wheat starch has over cornstarch. During the war, when tapioca starch was unavailable and cornstarch extremely scarce and high priced, some wheat starch was used—the exact amount has never been officially recorded. But the producers of wheat starch do not expect any permanent business in the paper field and have sought markets elsewhere—e.g., in the laundry industry and for special adhesives outside the paper field.

The Tariff Commission has estimated that about two thirds of the cost of corn starch is the corn, the price of which is indeed variable—depending upon the volume produced and the demand for it from food manufacturers, for livestock, and for industrial uses (*44*). When the demand is great for corn sugars, syrups, corn oil, and feed, the price of starch is affected. Even though the corn refining industry, often spoken of as the wet-milling industry, uses only about 4% (on the average) of the total corn crop (*16*), it is an important segment of the industry. Within that small segment, dextrose, syrups, and dextrins make up a larger proportion than starch. They have grown more important within the last ten years, when 59% of the total went to those purposes and 41% to starch. A fourth of the corn starch used went to the food industry in 1937, a fifth went to textiles, and nearly a sixth went to the paper mills (*37*). However, in the forties, papermaking plus the paper converting uses of laminating and corrugating together consumed more cornstarch than textiles and nearly as much as the entire food industry including the amounts going to brewers. Paper producers alone in the first six months of 1947 accounted for 17.5% of the total domestic and export cornstarch sales; textile manufacturers accounted for 17.08%. But papermaking plus the conversion uses of laminating and corrugating took 22.1% of the total domestic and export sales, whereas the food uses (such as baking, confectionery, chewing gum, miscellaneous foods, and brewers) made up 23.5% (*37*). However, this is a low percentage because much of the so-called packaged starch (sold by grocers) is a food item and undoubtedly many of the repacked items should be classified as food, although from the official statistics these amounts are difficult to determine. Table V gives the amounts of cornstarch consumed by the paper industry both in the manufacture of paper and in the conversion uses of laminating and corrugating.

Long-time trends are hard to establish in the consumption of starch because of the lack of statistical data. It has been estimated that the total quantities of starch used by the paper industry have not only increased because of the increase in the amount of paper produced, but the per ton usage has also increased, which evidently means that starch is being used instead of other materials, such as sodium silicate. Much more knowledge as to how to use starch has become available in recent years, especially regarding the starch precipitation process which makes it possible to add simple pearl starch properly boiled to the paper stock after the jordan, and quantitatively precipitate it

Table V. Cornstarch Consumption Total and by Paper Industry (Millions of Pounds)

Year	*Total domestic starch products sold*	*Cornstarch consumed by paper industry*[a]	*Percentage consumed by paper industry*
1927	650.1	71.6	11.0
1928	611.6	72.1	11.8
1929	658.3	76.2	11.6
1930	560.9	67.7	12.1
1931	552.6	57.3	10.4
1932	481.1	54.1	11.3
1933	681.7	81.3	11.9
1934	606.0	62.2	10.3
1935	592.1	70.2	11.9
1936	801.0	97.7	12.2
1937	684.8	89.2	13.0
1938	726.5	90.0	12.4
1939	821.0	107.3	13.1
1940	838.8	149.0	17.8
1941	1,228.2	271.6	22.1
1942	1,314.8	261.5	19.9
1943	1,351.1	287.8	21.3
1944	1,108.2	246.4	22.2
1945	1,142.4	271.6	23.8
1946	1,161.6	266.4	22.9
1947	1,381.1	346.2	25.0
1948	1,318.8	354.8	26.9

SOURCE: Sales Reports of Corn Refiners Industry, Grain Branch, Product and Marketing Division, U. S. Department of Agriculture.

[a] These data on the consumption by the paper industry are not exactly comparable from year to year, because of changes in classification. From 1927 through 1934, they include consumption by paper, paper box, paste, billboard, and asbestos manufacturers. From 1935 through 1937, U. S. Tariff Commission data are used. For 1938 the amount used for the conversion use of laminating and corrugating has been estimated and added. For the years 1939 to the present time, the two items reported by the Grain Branch—"paper mills" and "laminating and corrugating"—have been lumped together as representing the paper manufacturing and the paper conversion uses. Of the total corn starch consumed in paper manufacturing and the paper conversion of "laminating and corrugating," the latter use in the last two years makes up 20% and paper manufacturing 80%.

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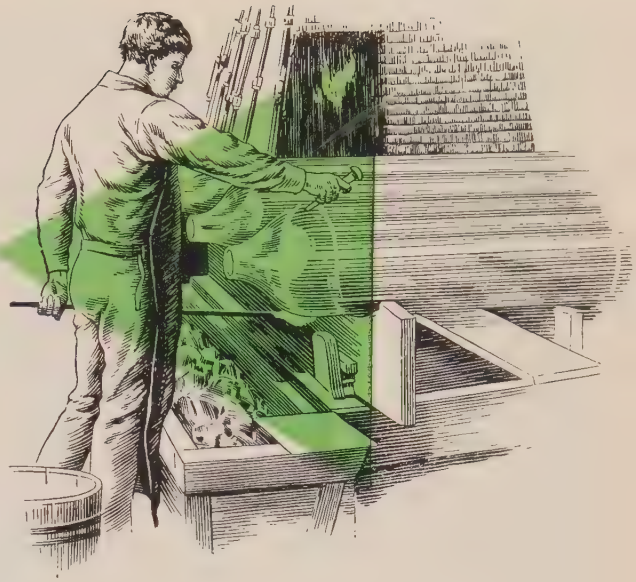

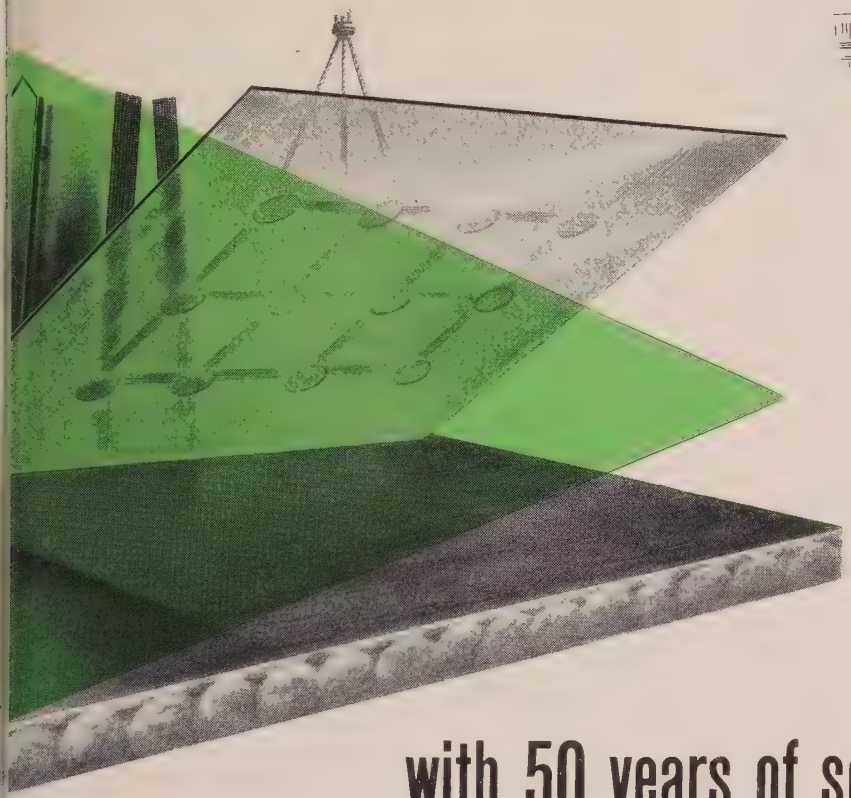

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upon the fibers so that it can be completely accounted for in the paper and give all the benefits that specially converted starches are claimed to have.

GLUE

Glue is used in the paper industry principally for sizing and as an adhesive, particularly in such products as gummed paper and containers. It is a waterproofing agent when used with formaldehyde. It is used with other materials in coating and to increase retention of fillers. When tub sizing was the only method used by paper manufacturers, a thin glue was in great demand. Today its use in most beater sizing is considered a wasteful procedure, but it is still used as a surface sizing.

According to the use-pattern established for allocation purposes by the War Production Board, the largest single use is gummed paper and tape which accounted for 27% of the total supply during the 1944–1945 allocation period. Adhesives (other than for gummed tape) used the next largest amount and abrasives the third largest amount. Glue is used also in the manufacture of containers which, when added to the other paper uses, raises the percentage going to paper or paper products to 37%. Nonpaper uses include textiles, matches, woodworking, bookbinding, gaskets, cork products, and a number of small miscellaneous products. During the short period when the supply of animal glue was allocated by the War Production Board the end-use pattern shown in Table VI was established.

Table VI. End-Use Pattern for Animal Glue
(Thousands of Pounds)

July 1, 1944–June 30, 1945

		%
Total estimated supply	152,953	100.0
Exported	1,868	1.2
Total domestic supply	151,085	98.9
Total paper	56,075	36.7
Gummed paper and tape	41,253	27.0
Paper and paper products	9,606	6.3
Containers	5,216	3.4
Adhesives	17,039	11.1
Abrasives	12,656	8.3
All other uses	65,315	42.7

Source: Bureau of Census, Facts for Industry Series 6-8-52 (March 17, 1947).

That the total allocation made by the War Production Board was too high is evident in later production statistics, even though allocations were permitted only for identifiable military and essential civilian requirements. The record does not show the uses which suffered in the scramble for the actual decreased supply. We know that it was not until 1947 that production reached the level desired for the allocation and that supply had only then begun to approximate demand. The increase of stocks between 1946 and 1947 would seem to bear this out. The maintenance of high prices might indicate that supply had not exceeded demand, except for the fact that glues appear to have, at present, a somewhat inelastic demand. However, the difference between hide and bone glue prices might account for the big jump in production of bone glue between 1946 and 1947.

In the early thirties 90% of all the glue consumed by boxes and 87% of the glue used in gummed paper and tape was green bone glue. However, 63% of the glue used in paper bags and wallpaper was hide glue (*43*). In that survey over half the green bone glue was used in the manufacture of gummed paper and tape and 13% was used for boxes. This breakdown of types of glue used by the paper industry is not available for later dates. Under OPA, black markets in meat developed which had dire effects on both the production of glue and the ability of paper manufacturers to buy hides for their animal size. When price controls on meat were lifted, the production of glue increased (Table VII). Since then, demand has remained heavy and prices have stayed firm.

Table VII. U. S. Production of Animal Glue (Hide, Extracted, and Green Bone Glue) (Thousands of Pounds)

Year	*Production*	*Year*	*Production*
1927	112,303	1938	87,836
1928	103,621	1939	101,092
1929	106,381	1940	107,477
1930	103,066	1941	134,492
1931	89,400	1942	139,252
1932	61,671	1943	126,679
1933	49,911	1944	137,741
1934	...	1945	134,411
1935	87,022	1946	139,232
1936	110,074	1947	157,276
1937	121,641		

Source: 1927–1937 data from U. S. Tariff Commission (*43*); 1938–1946 data from Bureau of Census, sent by private correspondence from Chemicals & Drugs Section, Office of Domestic Commerce, Oct. 1, 1947. 1947 data from Bureau of Census, in *Oil, Paint and Drug Reporter*, April 26, 1948.

Production statistics on glue have become a part of the monthly report on chemicals issued by the Bureau of Census. Price data are most readily available in the *Oil, Paint and Drug Reporter*. Few estimated consumption figures are available other than the above noted allocation end-use pattern and the depression consumption pattern of the early thirties tabulated by the U. S. Tariff Commission, neither of which would apply in the present situation. But no other data exist.

Animal glues compete in the paper market with casein glues and with the vegetable glues of tapioca, corn starch, and soybean and, within recent years, with synthetic resins, although the greater cost of the latter has meant that they have not been a competitive factor in the paper field as yet. Hide glue and extracted bone glue are both imported. Imports in 1938 dropped to only 2% of the domestic output, so that competition is dependent greatly on the condition of the domestic production.

CASEIN

Casein is used principally as a pigment binder in the coating of paper. It is an adhesive and is sometimes used as a stabilizer for rosin size. Casein is not used for inexpensive papers because of its relatively high cost and cannot be used in the furnish of some papers because of odor. However, enough casein is used in paper to account for the largest percentage of the supply, even though we do not know the exact volume now being consumed by the paper industry.

Use-patterns were established during the war in allocations and estimates have been made by the marketing editors of *Chemical Engineering* and by

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others. Table VIII gives the estimated proportion of the total supply of casein consumed by the paper industry. The use-pattern of casein established by allocation during World War II (Table IX) shows that, even though paper was deemed less essential than some of the other industrial uses, it was still allowed to take the largest percentage. Adhesives took the next largest amount, paints used the third highest, and plastics the fourth. The allocations were set by industrial men, each of whom estimated how much his industry would need. Although they are somewhat at variance with actual consumption (which was somewhat less than the allocation), they represent the only use-pattern available.

Table VIII. Casein Production, Imports, Paper Consumption (Millions of Pounds)

Year	*Domestic production*[a]	*Imports for consumption*[b]	*Supply*[c]	*Estimated paper consumption*[d]
1927	18.0	24.2	42.2	40.0
1928	22.2	28.7	50.9	46.0
1929	30.5	27.6	58.1	37.0 (Census)
1930	42.0	18.5	60.5	32.0
1931	35.3	3.5	38.8	30.0
1932	24.4	1.2	25.6	30.0
1933	24.1	8.1	32.2	34.0
1934	37.3	1.5	38.8	34.0
1935	37.6	3.2	40.8	36.0
1936	46.1	16.2	62.3	40.0
1937	67.5	5.2	72.7	36.0
1938	48.5	0.4	48.9	..
1939	40.9	15.8	56.7	35.2 (Census)
1940	46.6	24.5	71.1	42.0
1941	47.3	41.5	88.8	48.0
1942	42.3	16.8	59.1	26.0
1943	18.4	32.0	50.4	23.2
1944	15.3	47.8	63.1	26.0
1945	12.3	55.0	67.3	32.6
1946	18.2	41.7	59.9	35.0
1947	35.7	20.9	56.6	15.0
1948	14.1[e]	40.6	54.7	..

Sources:
[a] Production of manufactured dairy products, annual report, Bureau of Agricultural Economics, U. S. Department of Agriculture; 1927–1942 data from Anderson's table (*1*), other data directly from the Bureau in annual reports and in summaries of monthly data appearing in monthly summaries: dry casein.
[b] Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce; data from 1927 through 1945, from a table prepared by Anderson (*1*); other data directly from Bureau.
[c] Production plus imports.
[d] With the exception of the Census years, 1929 and 1939, all data are estimated. From 1927 through 1936 from *Chem. Met. Eng.* **44,** No. 2: 67 (Feb., 1937). 1937 data from *Chem. Met. Eng.* **44,** No. 9: 582 (Sept., 1937); data from 1940 to 1945 are from industry estimates to War Production Board and of those data 1943 and 1944 represent allocations to the various industries and which were probably somewhat higher than actual consumption; 1945, 1946, and 1947 are estimates directly from large suppliers.
[e] Estimated by Bureau of Agricultural Economics.

During the war, much of the skim milk was used in powdered form by the Army and by the rubber industry. The OPA price of separated cream was so low that approximately a quarter of a million farmers who had sold cream sold only whole milk. Consequently, the nonfat solids were not available. The support features under the Steagall Act stimulated the edible products of milk as opposed to casein, decreasing the supply. New synthetic materials are consuming more casein and there has been an increased demand for coating pigments and binders in papermaking. With less available supplies from domestic producers and with domestic demand increasing, the American demand for Argentina casein rose. Moreover, the demand for the substitutes for casein also increased. But corn and potato starches were scarce and soybean protein was largely used for war purposes. Some mills turned to hide glue when they could get it, to corn dextrin, and to grain flours, including soya flour. With an OPA ceiling price of 24 cents a pound, and even when raised to 33 cents, imports of Argentina casein were practically prohibitive at 42 cents. The tariff rate on casein from Argentina is $2^3/_4$ cents per pound and from all other countries, $5^1/_2$ cents. During the war some casein came from Canada, Uruguay, and Brazil, according to the Department of Commerce, although the volume was very small. After OPA was abolished in the fall of 1946, prices reached a high level of 55 cents per pound; this caused American producers to put more casein on the market which, in due time, of course, caused the price to drop to 22 cents before it rallied and stayed around 32 cents until early in 1949, when the price again dropped to 20–23 cents per pound. The Argentina casein price has been kept high artificially by that government. In the past when exports fell very low, the government was forced to lower the export price to be closer to the American domestic price.

The United States was the largest producer of casein in 1939 in the world market, although Argentina was a close second as Table X shows.

Argentina today produces more casein than any other country in the world. Domestic production varies with the price and when the price is low consumers are forced to get their supply by increasing imports. Domestic production in 1948 dropped largely because of heavy buying of milk powder by the U. S. government for shipment abroad (*45*). In 1943, there were 112 plants producing casein in the United States. The main centers of the domestic production in 1943 were Wisconsin, California, and New York, although since then there has been a decrease in the amounts produced in these states and an increase in casein production in

Table IX. Casein Allocations by War Production Board

Industry	*1943, %*	*1944, %*
Paper industry	46	38.6
Adhesives	15	13.9
Paint	11	8.4
Plastics	7	8.2
Building materials	4	2.9
Rubber compounds	3	4.2
Wall paper	2	...
Leather finishing	1	1.3
All others (food, medicinals, pharmaceuticals, textile, sizing, insecticides)	11	22.5

Source: 1943 data published in Industrial Reference Service, Part 2, No. 18, May, 1945. Casein. 1944 data appear in "Casein in the War Program," Facts for Industry Series, 6-8-6, released April 17, 1946.

Table X. World Production of Casein in 1939 (In Thousands of Pounds)

Country	*Quantity*	*Per cent of total*
United States	40,878	24.7
Argentina	39,348	23.8
France	11,962	7.2
Norway	6,393	3.9
Australia	6,000[a]	3.6
New Zealand	6,000[a]	3.6
Netherlands	4,543	2.7
All other	50,223	30.5
	165,347	100.0

Source: Bureau of Agricultural Economics, U. S. Department of Agriculture, published in Industrial Reference Service, Vol. 3, Part 2, No. 18, May, 1945. Casein. Published by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.
[a] Estimated.

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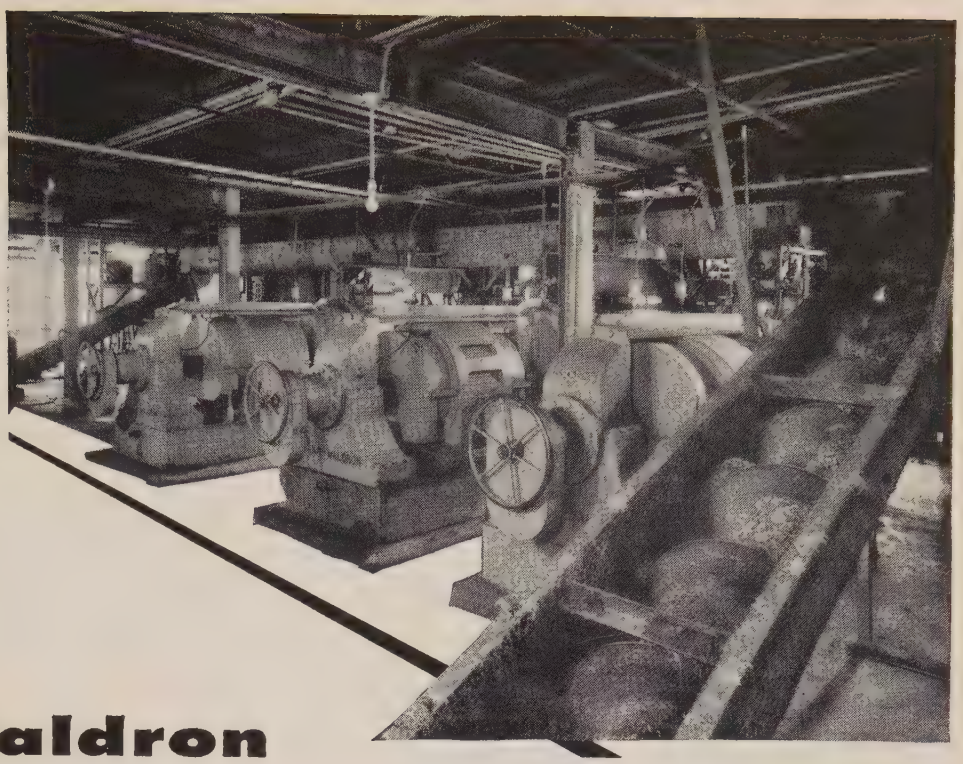

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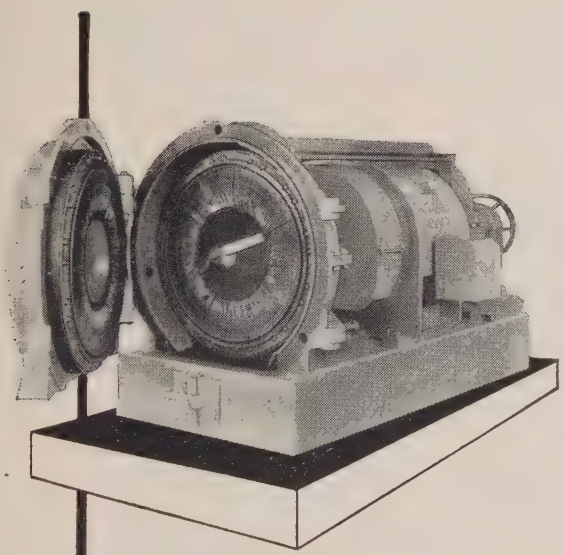

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such states as Idaho, Illinois, Minnesota, and Missouri.

Soybean protein is a substitute for casein in paper coating. Reig Milner of the Northern Regional Laboratory estimates that the three concerns producing purified soybean casein make about 50 tons daily or approximately 15,000 tons per year. Other estimates have indicated a production of between 10,000 to 12,000 tons. Of the total supply, it is probable, according to one of the suppliers, that paper coating takes about 60% or somewhere in the neighborhood of 6000 to 8000 tons, although no actual consumption data are available for any particular year. The paint industry and miscellaneous uses consume the rest. To the extent that soybean protein is used by the paper industry, it influences the consumption of casein. The determination of which material is used, however, is largely one of price.

WAXES

Waxes are used in the paper industry primarily as a waterproofing agent in such products as waxed paper—its chief use—and in such papers as kraft wrapping, millboard, fiberboard, food boards (milk bottle caps and ice cream cartons), dielectric paper, transfer and photographic papers, and lithographic papers. It is also used as a sizing agent either with or without rosin.

The chief type of wax used by the paper industry is paraffin, a crystalline wax made from crude petroleum. Statistics are not available on the usage of wax by the paper industry, but estimates are possible from scattered data. It is estimated that bread wraps alone take the largest amount of wax of any single paper product. If the items of films are included in the paper consumption figure (cellophane, cellulose acetate, and other pulp products), the pulp and paper industry probably uses about 75% of all the microcrystalline or amorphous wax. In 1943, the War Production Board estimated that 16,000 tons of microcrystalline wax were used with paper.

The consumption of wax for waxed paper alone has been estimated to be 84,000 tons in 1942, 94,000 in 1943, 100,000 in 1945, 120,000 tons in 1946, and between 135,000 and 140,000 tons for both the years 1947 and 1948.* The amount of wax used for sizing purposes has been estimated by various wax suppliers to be from 2500 to 7000 tons. No actual reporting of this usage has ever been made.

The Chemicals Division of the War Production Board estimated that, in 1943, 160,000 tons of paraffin wax were used by the paper industry. With the 16,000 tons of microcrystalline wax also estimated by the same division, the total consumption of petroleum wax was 176,000 tons. If these estimates are approximately correct and the Waxed Paper Institute's data are correct, waxed paper is taking only about 53% of the wax used by the paper industry and the uses other than for waxed paper are much larger than is generally assumed. In 1946, waxed paper alone took about a fourth of the domestic production of paraffin wax, a figure about equivalent to the amount exported. If that is approximately 53% of the total used by the paper industry, the actual consumption was 226,000 tons or closer to half of the domestic production of paraffin alone. It is obvious that the existing data on this subject are scarce indeed. Recent interest on the part of petroleum companies might indicate that enough pressure may shortly be exerted to get the Bureau of Mines to obtain industry consumption data as well as production and supply data.

Table XI. Petroleum Wax Supply (Millions of Pounds)

Year	*Production*	*Imports*	*Exports*	*New supply*[a]	*Domestic, total demand*[b]
1916	386.2	9.3	376.8	275.2	210.7
1918	505.1	5.6	235.5	173.6	200.7
1920	541.2	7.6	375.3	184.9	187.6
1922	462.0	7.4	284.5	146.5	221.6
1924	516.5	12.9	382.8	320.2	251.3
1926	645.8	10.0	335.6	262.2	302.5
1928	630.1	24.7	392.7	285.1	242.1
1930	547.7	30.4	293.0	257.9	264.5
1932	458.9	33.3	235.3	307.1	240.0
1934	468.7	37.3	199.0	302.2	301.5
1936	472.9	16.7	187.3	262.9	278.5
1938	435.4	28.9	201.4	406.5	356.9
1940	513.2	83.1	190.0	556.8	546.2
1942	700.6	9.7	153.5	645.0	633.2
1944	807.2	..	162.2	661.4	673.1
1946	840.8	0.3	201.8	640.0	635.8
1947	1,014.7	1.1	310.2	705.6	693.6
1948	987.5	8.2	270.9	724.8	607.6

SOURCE: Minerals Yearbook, annually. 1946 and 1947 data directly from the Bureau of Mines, Petroleum Economics Branch. 1948 data estimated from monthly petroleum statements, Mineral Industry Surveys, Bureau of Mines.

[a] Supply is defined as production plus imports minus exports. It is evident that, in any given year, supply may have to be supplemented by stocks on hand in order to equal demand.

[b] Demand is shown statistically by the sum of production, imports, and stocks at the beginning of the year, less exports and stocks at the end of the year.

The over-all supply of petroleum wax available to the various consumers is tabulated yearly by the Bureau of Mines as shown in Table XI.

GLYCERIN

Glycerin is used in the paper industry chiefly as a softening agent in glassine, greaseproof, and vegetable parchment papers; in some other papers, such as stencil, duplicating, and some printing papers; and in a number of special converted paper products, such as drapes. A considerable tonnage is used in pulp products such as cellulose films and meat casings.

The largest percentage of the glycerin supply is used for synthetic resins, some of which undoubtedly are incorporated into paper specialties. The next largest use of glycerin during the war was, of course, for dynamite and nitroglycerin. Drugs, pharmaceuticals, and tobacco were the next largest users.

The only industrial consumption data available are from the Department of Agriculture, collected under War Food Order No. 34 for the years 1940–1943. There are no actual reporting statistics on industrial consumption for other years. Table XII indicates the reported uses for those years.

As Table XIII indicates, most of the volume listed as pulp and paper products goes into cellulose films and meat casings. The use breakdown of the total amount of glycerin consumed by the pulp and paper industry is shown in Table XIII.

Estimates appeared during the war for glycerin consumption in paper which omitted the use in cellulose films and meat casings. In the War Production Board's Materials Handbook, an estimate of 1,768,000 pounds

* Estimated on the basis of the Wax Paper Institute's statement that a third of the finished waxed paper is wax.

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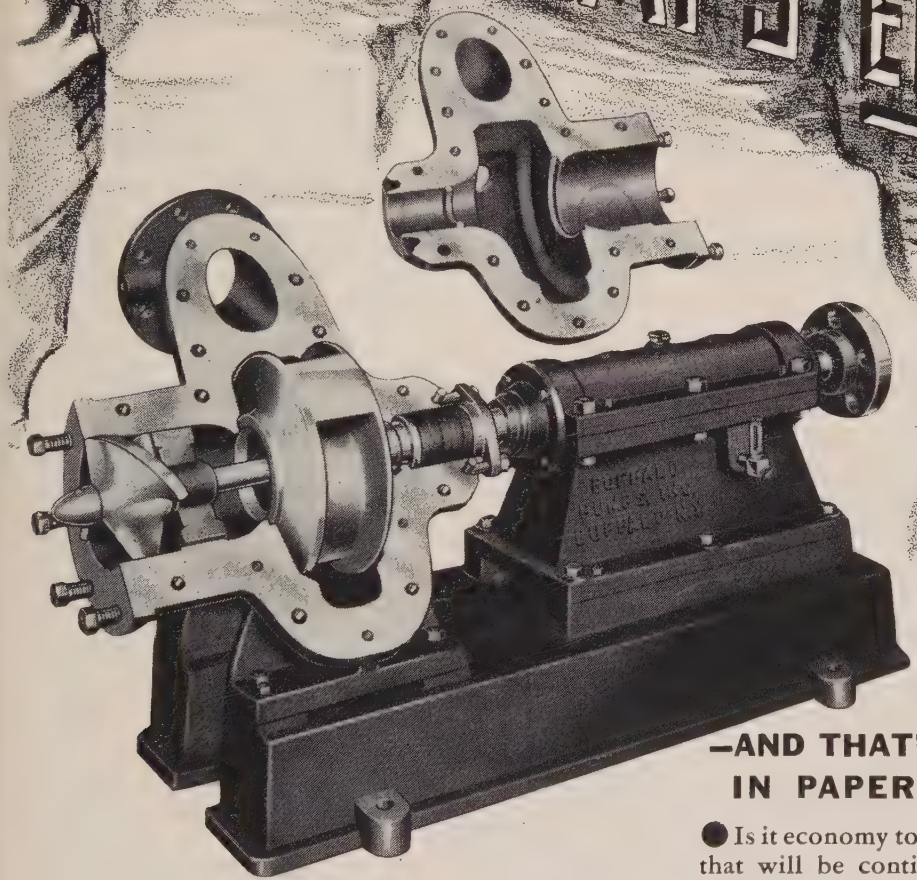

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Table XII. Glycerin Consumption[a] (Thousands of Pounds)

	1940	1941	1942	1943[b]
Total Consumption	140,359	175,135	166,350	161,347
Industry use ranked on 1940 basis				
Synthetic resins and ester gum	27,723	40,234	41,863	52,488
Tobacco	24,833	25,793	20,071	7,652
Dynamite and nitroglycerin	22,586	30,624	36,445	40,917
Pulp and paper products[c]	21,137	22,521	18,967	16,480
Dentifrices and toilet articles	9,204	11,313	7,567	2,823
Drugs and pharmaceuticals	8,885	10,874	9,304	9,798
Gaskets and cork products	6,030	8,019	8,638	8,372
Other uses[d]	19,961	25,757	23,495	22,817

SOURCE: Adapted from table prepared by National Industrial Conference Board (*25*, Table 12).
[a] Approximately 97.5% glycerol.
[b] Allocations, not actual consumption.
[c] Excluding amounts consumed as synthetic resins and as adhesives.
[d] Rubber and textile processing, printers' supplies, leather, adhesives beverages, margarine.

Table XIV. Supply of Refined Glycerin (Includes Chemically Pure and High-Gravity Yellow Distilled Grades) (Thousands of Pounds)

Year	Production	Imports	Exports	Total Domestic Supply[a]
1929	113,140	5493	1,374	118,259
1931	102,510	1976	328	104,158
1933	107,853	2776	...	110,629[a]
1935	118,727	69	...	118,796[b]
1937	122,399	7535	1,375	128,559
1939	154,778	330	7,399	147,709
1941	194,327	...	9,585	184,742
1943	180,581	371	24,473	156,479
1945	159,709	...	7,598	152,111
1947	191,153	807	4,378	187,582
1948	196,279	420	3,834	192,865

SOURCE: U. S. Bureau of Census, Chemical Facts and Figures, 1st ed. 1940, pp. 68, 162, 181; 2nd ed., 1946, pp. 195, 338, 359; import and export data from 1929 to 1936 from Statistical Abstract of the United States; for 1947 and 1948, U. S. Bureau of Census, Facts for Industry Series M17, Fats and Oils, monthly data added for yearly total.
[a] Supply is defined without reference to stocks, as production plus imports minus exports.
[b] Exports omitted.

is given for 1943. Early in 1941 the paper industry in cooperation with statisticians in the Office of Production Management, estimated various industry requirements for chemicals and in those data the paper industry's consumption of glycerin is given as 12,000,000 pounds. E. N. Poor (*26*) estimated 1942 consumption on the basis of 1941 data as 2600 tons.

The Bureau of Census reports monthly the production, imports, and exports of refined glycerin (Table XIV).

After the war, glycerin prices reached a high of 55 cents per pound. However, competition with synthetic glycerin lowered the price of the natural product, made by the two largest soap makers, Procter and Gamble and Lever Brothers, to the level of Shell Oil's synthetic product of 24 cents per pound. This level is close to the prewar peak, although the depression price was down to the general level of from 10 to 15 cents per pound (*8*). The use of glycerin in paper products is likely to increase with this new price level and the added supply from synthetic sources as well as from the natural products.

SYNTHETIC RESINS

The use of synthetic resins to impart special functional properties to paper—such as dry and wet strength, waterproofness, grease resistance, water-vapor proofness, etc.—was initiated before the war. However, the extensive use of resins to produce specialty military papers during the war caused the development of resins and of their application to paper to be pushed at an accelerated rate.

Wet-strength paper for maps, parachutes, lint-free lens tissues, as a substitute for burlap bags and binders twine, and for shipping tags introduced many ideas for the use of resins in peacetime paper products. Water- and moisture-resistant papers and boards used for all kinds of packaging made possible the safe arrival of military equipment, food, and other necessary army provisions in all parts of the world. Such uses have already become important in peacetime foreign trade. Such items as V-box board, waterproof closure tape, water-resistant label paper, shipping sacks, and waterproof envelopes for papers which might be subjected to water or moisture have all introduced new methods of improving quality to meet competition in the packaging field. Since the war, a number of new uses have been found for resins which aid in papermaking. A combination of urea and starch as a sizing agent and the use of urea resins and alkyds to improve paper transparency are examples (*27*, 1947 report).

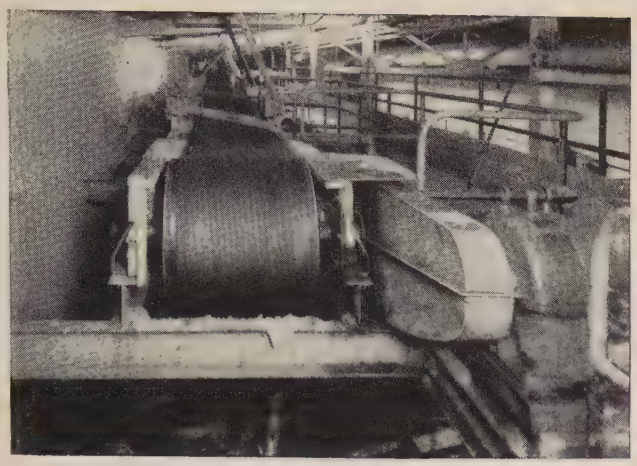
Resins themselves have undergone considerable development during and since the war so that they are better servants of many industries, including the relatively new plastics industry. The paper industry has been quick to make use of them, particularly now that practically all types of resins are no longer scarce. It is possible that, with the return of normal competition in the paper industry, improved quality will be sought as a sales advantage through the special use of certain resins. If it is important in the use of a paper item to have better water and scuff resistance and resins can impart this quality, competition will help increase the market for the resins.

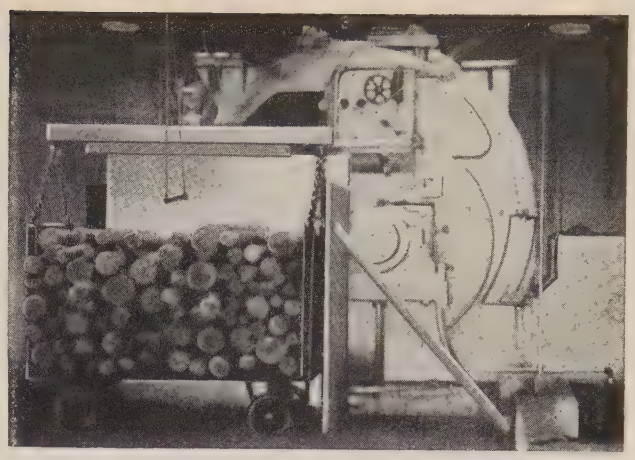
Statistically, we are only beginning to be informed about the relative markets for resins in the various industries. The Bureau of Census and the United States Tariff Commission tabulate the production and sales of plastics materials according to industrial usage. The paper use has not been sufficient, or the interest for data keen enough, to warrant separate industry reporting.

Table XIII. Consumption of Glycerin by Pulp and Paper Industry, 1940–1943 (Thousands of Pounds)

	1943[a]		1942		1941		1940	
Total pulp-paper use	16,480	100.0%	18,967	100.0%	22,521	100.0%	1,137	100.0%
Cellulose films and meat casings	11,901	72.3	15,946	84.0	18,973	84.6	18,483	87.6
Glassine, greaseproof, and vegetable parchment	2,765	16.8	1,511	8.0	2,008	8.8	1,598	7.6
Other papers	1,814	10.9	1,510	8.0	1,540	6.6	1,056	4.8

SOURCE: Department of Agriculture, adapted from National Industrial Conference Board table.
[a] Allocations.





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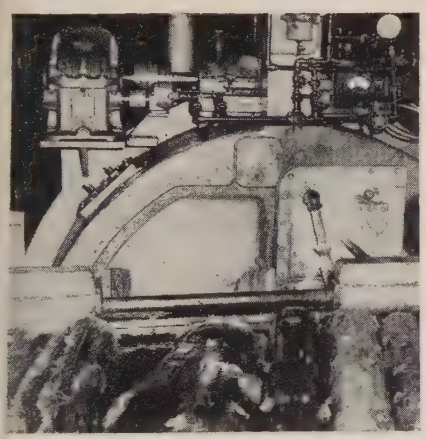

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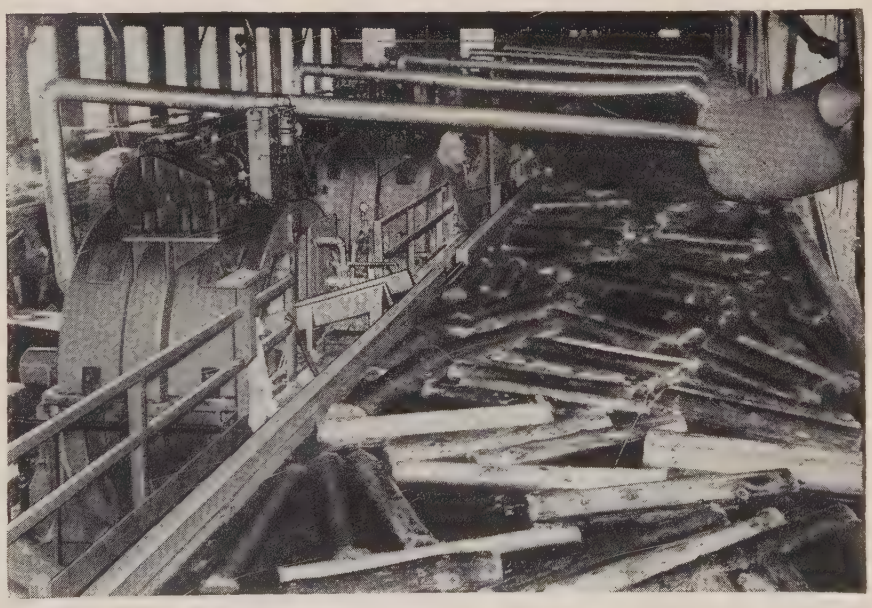
Large Labor Savings

Easy loading is a feature that is responsible for large labor savings with the Roberts Grinder, as high as 70% on some installations. Many maintenance needs are eliminated. Grinding four and five foot wood cuts preparation costs, reduces waste. Thousands of man-hours are saved annually. Lower labor needs all down the line is an important item in cutting the cost per ton to manufacture ground-wood pulp. It is only one of the many advantages of the high-speed continuous Roberts Grinder.



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At first, its use was statistically included with that of textiles and leather; then leather treatment was dropped, so that the present statistics report the paper industry usage along with that of the textile industry. For those who have some method of determining the relative usage of each of the two industries or for those who find some use for statistics which fail to distinguish between two (or when leather was included, three) important industries, this sort of tabulation may not be disappointing.

In 1944, resins were classified into two types statistically by the U. S. Tariff Commission in its survey. Of the cyclic (benzenoid) group, textile, paper, and leather industries consumed 0.2% of the total amount sold. Of the acyclic (nonbenzenoid) group these industries accounted for 8.7% of the total sales. Resins were later classified more specifically and statistics on urea and melamine resins and of vinyl resins—the two groups of most interest to papermakers—became available. The textile, paper, and leather industries bought 14,159,000 pounds of urea and melamine resins for treatment purposes in 1946. This use accounted for 15.7% of the total amount of these resins sold that year. In the same year, 21,169,000 tons or about 15% of the vinyl resins sold went to these same industries. The paper industry also used a small amount of other resins which are not classified separately for that year. The urea and melamine tonnage used for "textile and paper treating" increased in both 1947 and 1948, the latter volume being around 20 million pounds or about 25% of the total sold (*41*, March, 1949: 29–30). The tonnage of vinyl resins used in "textile and paper coating" decreased slightly in 1947, but in 1948, it was 33, 558,000 pounds, or an increase of 80% over 1947. All the uses of vinyl resins increased, so that the textile and paper use still accounted for about the same percentage (15%) of the total shipments as in 1946.

Adhesives consume the largest amount of the urea and melamine resins and sheeting, and films and molding products consume the largest tonnages of the vinyl resins. If we classify paper- and pulp-base plastics as pulp and paper products, which they are, but which the Bureau of Census does not do, then the total consumption (which would include the phenol-formaldehyde resins) by the pulp and paper industry would be considerably increased. No accurate data on that consumption exist, however, to aid us in considering to what extent the tonnage would be increased by that addition.

Some effort is being made to get the Bureau of Census to separate the textile and paper uses of resins but until this occurs there are no statistical supply-demand data of much value to the paper industry. Estimates have appeared from time to time by suppliers but in this highly flexible and rapidly changing new field—with new resins and new uses constantly coming into the picture—a past estimate of a particular resin consumption is not of great value in predicting the future consumption of all synthetic resins by the pulp and paper industry.

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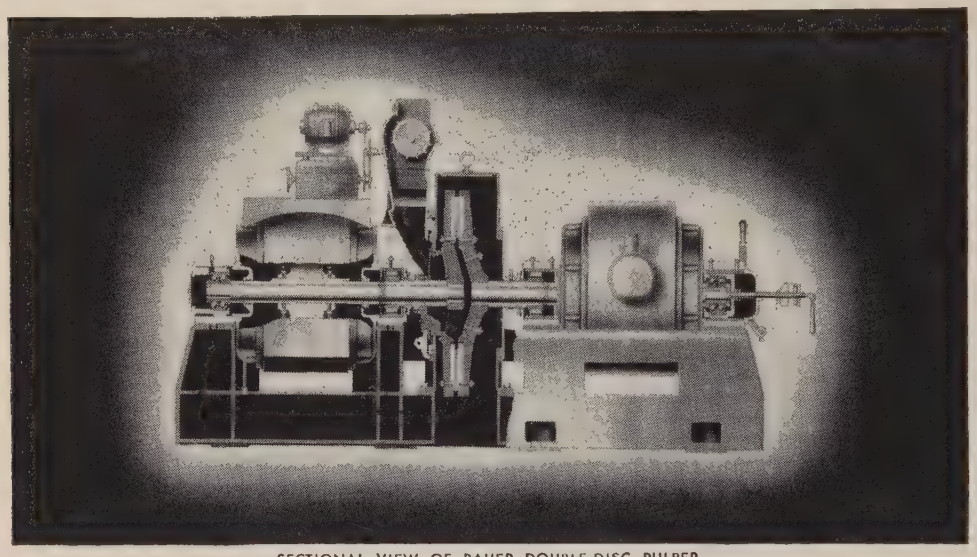

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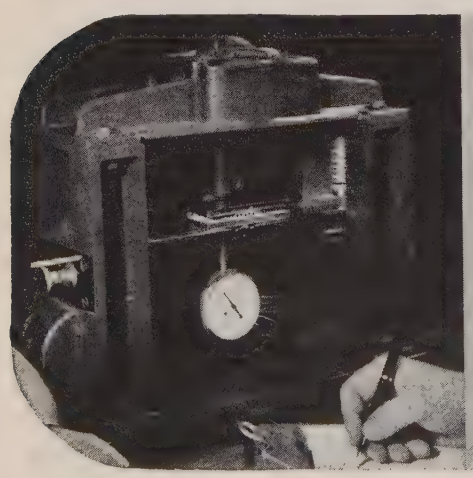

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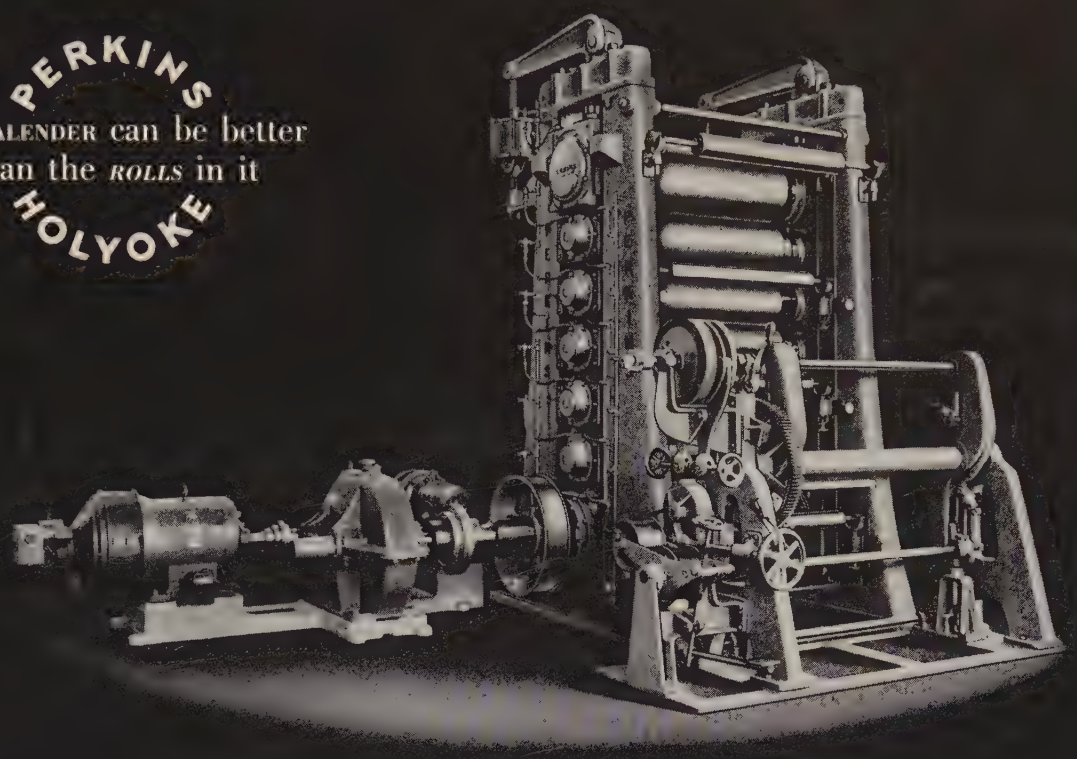

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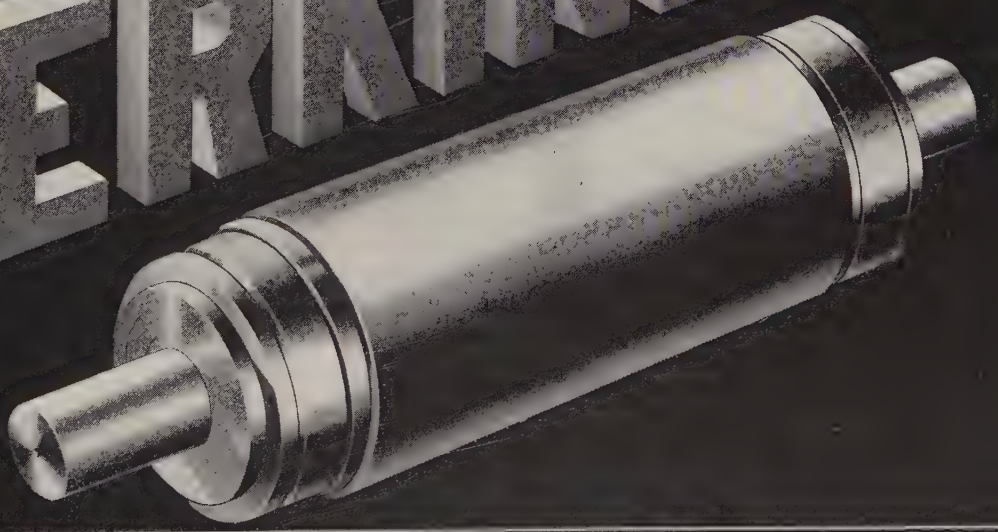

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The Recovery Unit itself is designed to handle 611,000 pounds of dry solids every 24 hours. It is designed for 750 pounds pressure and operates at a pressure of 700 pounds per square inch with a temperature of 725° F.

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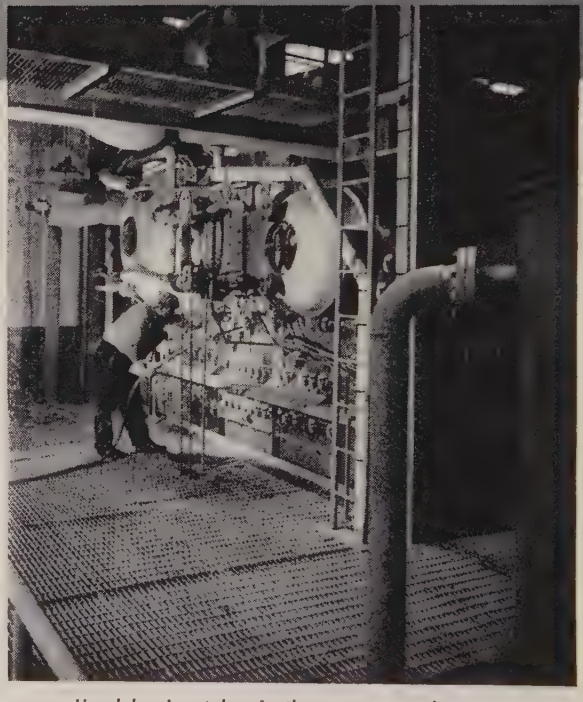

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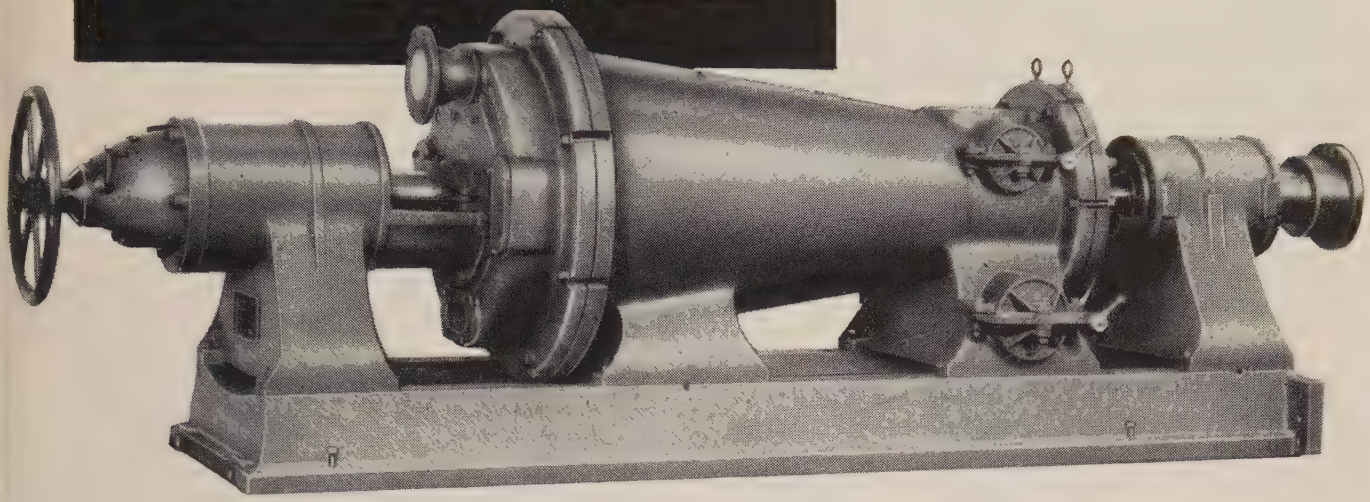

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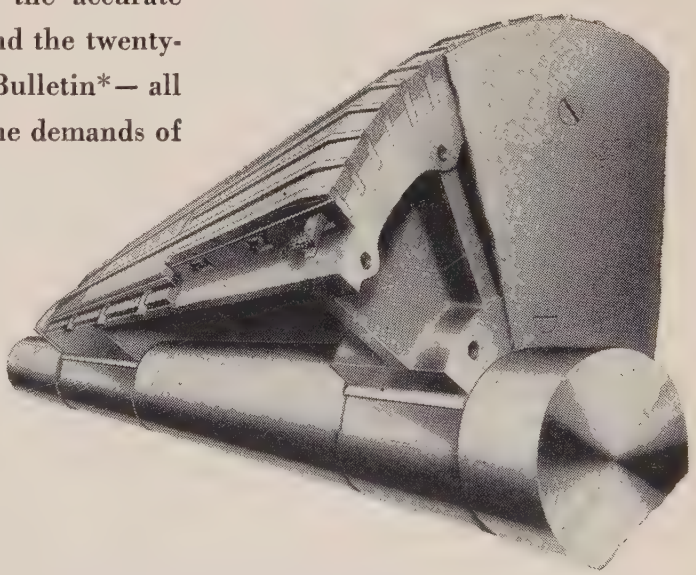

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Nonfibrous Raw Materials—1949

EDWARD N. POOR

Pulp, paper, and paperboard production continued at a high level during 1949 although recent indices indicate a slight reduction over 1948.

The year experienced many conditions which interfered with normal trade. Monetary restrictions, currency fluctuations, artificial exchange rates, and labor upheavals distorted the distribution of pulp and paper products throughout the world. However, during the last quarter some semblance of stabilization seemed to be emerging.

During the year there appeared some chemical shortages but, in general, heavy demands were met. With some increases in raw material and fuel costs it is not expected that chemical prices will show much reduction during 1950.

CAUSTIC SODA

Ample supplies of caustic soda are available, and no price changes are contemplated. New uses are confined largely to the new processes being introduced in the chemical field and the replacement of soap powders with synthetic detergents. In 1950 the supply will continue to be ample but increasing costs prevent justification of lower prices.

SODA ASH

The market for soda ash has currently eased and is expected to continue so through 1950. A one price policy for carloads of soda ash, regardless of tonnage purchased, was put into effect. This resulted in price reductions for many consumers. No other price changes have occurred during 1949 or are anticipated for 1950.

Substantial quantities of soda ash have been used in semichemical pulping and in replacement of salt cake in the kraft industry. It is expected that the semichemical pulping process will continue to expand materially during the coming years.

Soda ash continues to be the cheapest and most commonly used form of alkali for pulp and paper manufacture. It can be converted readily to caustic soda, sulphite, sulphide, or hypochlorite, basic chemicals used in the industry. No economic substitute has been found to replace soda ash.

LIME

Chemical lime will be readily available during 1950 unless some unforeseen increase in production takes place in the basic industries.

It should be remembered that the price of chemical lime increased only about 20% over prewar prices and unless there is a reduction in fuel and raw materials used in the manufacture of chemical lime, it is not believed that there will be any change in chemical lime prices during 1950.

In a number of kraft pulp mills, they are mixing the small sized washed limestone and the carbonate sludge obtained from the kraft mill operation in their rotary kilns. This is done only when there is sufficient rotary kiln capacity to handle limestone plus all the sludge from daily operation.

SULPHUR

Sulphur for the paper industry continues to be available to supply all the demand, and the prospect for continued high demand for sulphur as a raw material in the paper industry during 1950 appears bright. There was no change in price during 1949.

A project to recover liquid SO_2 from the International Nickel Co.'s smelter at Copper Cliff, involving revision of the whole smelting operation and the use of tonnage oxygen, has been reported.

SULPHUR DIOXIDE

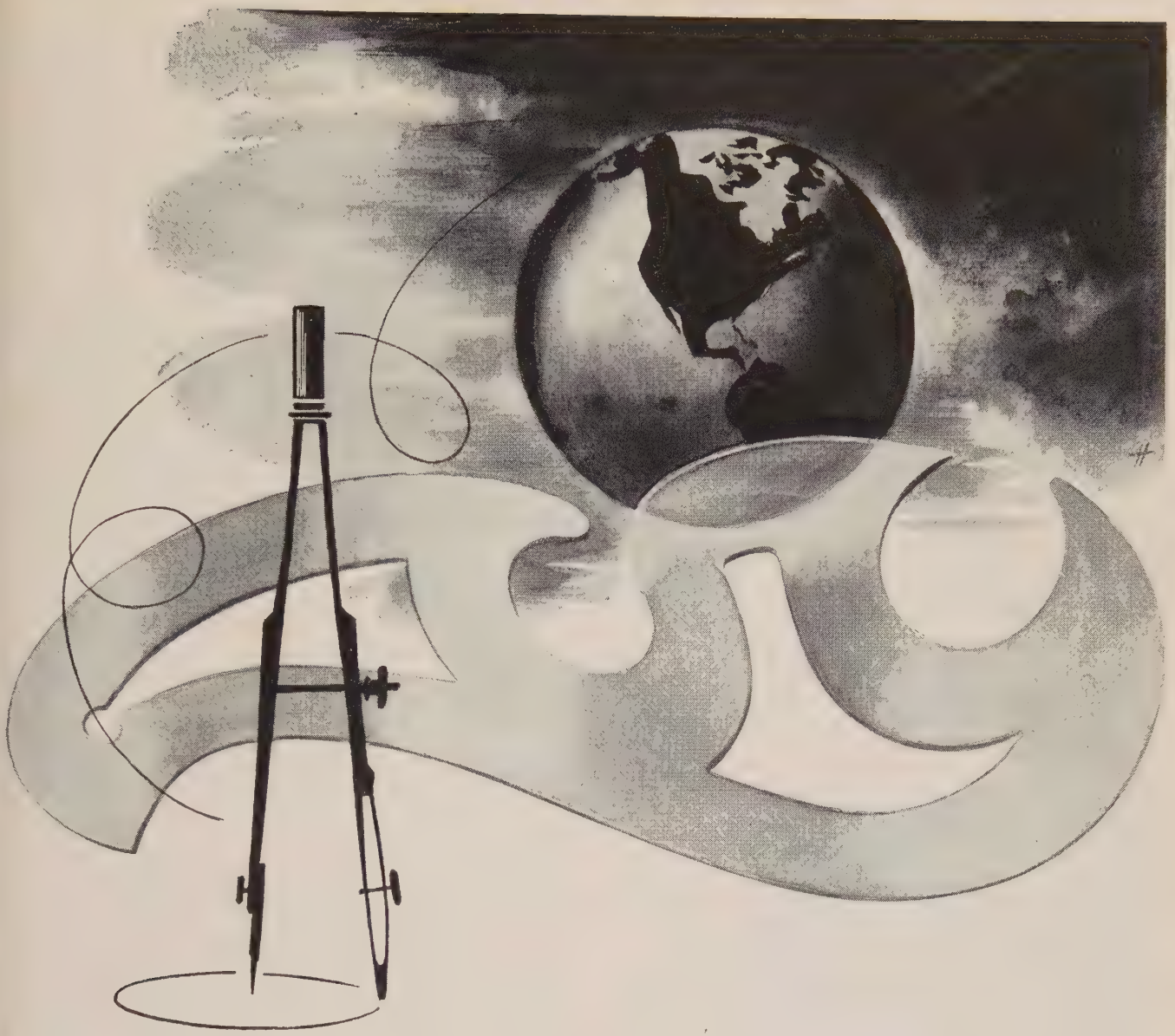
Liquid sulphur dioxide of high purity has been available for about a quarter century. In the early years of its production only modest quantities were available and the bulk of it was consumed as a refrigerant, but today, SO_2 is produced in ever increasing tonnages and its uses are legion. Within the last ten years industry has come to recognize the unique properties of liquid sulphur dioxide as a process chemical. There is ample evidence of this in the stepped-up production rate each year between 1937 and 1949. Much of this increased production was a response to the demand for new uses, but a significant portion represents a switch to liquid SO_2 from other forms of this reagent. Few technical reagents are obtainable at so high a purity (99.98%) for so low a cost. Of obvious importance are the economic advantages of a reagent which adds no residues to the end product, and which, for certain uses, can be so easily removed, recovered, and reused. To the processor and research worker alike, liquid sulphur dioxide presents unlimited possibilities.

The domestic production of sulphur dioxide has been steadily rising and has now reached the "thousands of tons level." Production capacity has kept well ahead of demand so plenty of material is available to industry.

Sulphur dioxide prices have followed the general price pattern of all chemicals for as production and demand increased, price has decreased. Even during the recent war years when prices, in general, skyrocketed SO_2 maintained a very modest level, and during the second quarter of 1949 the price was reduced.

Materials such as sulphur, bisulphites, meta bisulphites, and the like can be substitutes for SO_2

Edward N. Poor, member TAPPI; Chairman TAPPI Nonfibrous Raw Materials Committee; Hudson Pulp & Paper Corp., Augusta, Me.



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In today's world it takes seasoned experience and real "know-how" to forge ahead or even hold one's own. It doesn't take too much experience to suggest that anti-friction bearings should replace sleeve bearings on a paper machine—or that more dryers would clear the way for higher machine speed. Those things are pretty obvious. What wasn't so obvious was the deduction that the use of too much water was holding back the speed of the machine at a certain mill. Yet, a Shartle man only recently cleared away that mill's production bottleneck by proper study of the water consumption—an analysis that cost the mill not a cent but meant many thousands of dollars saved on water usage and tonnage gained. Black-Clawson, Shartle and Dilts engineers are qualified to make just such mill studies—are making them North, East, South and West almost every day in the year. Perhaps they could do you a good turn also. *Anything troubling you?* If so, lay it in the B-C-S-D lap.

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although the attempt to do so is usually cumbersome.

The domestic productive capacity is adequate to take care of a considerably increased demand before new or enlarged facilities will be required. Consequently no shortage is anticipated for 1950 or several years to come. New applications are requiring steadily increasing quantities of SO_2, but since the present price levels of this chemical are so modest it is not anticipated that these slowly increasing demands are likely to increase productive requirements to the point where significant manufacturing economies can be realized.

CHLORINE

Chlorine was in steady demand throughout 1949, but all requirements were met. There appear to be no new uses of chlorine or caustic soda in the pulp industry. New uses for chlorine, especially in the field of organic chemistry outside of the pulp industry, continue to be found as chlorine is a great tool of manufacture as well as a component of many products. Caustic soda is even more basic than chlorine and the uses are legion.

There appears to be no substitute for chlorine for pulp bleaching. The other halogens are neither technically nor economically suitable. Hydrogen peroxide has long had some specialized use in the textile industry and recently has been used for brightening groundwood pulp.

Prophecy is a dangerous pastime, but the fact that increased chlorine capacity is now building for production in 1950 indicates that the industry is reasonably optimistic as to the future.

SODIUM PEROXIDE

The consumption of sodium peroxide has kept pace with general market conditions, and the peroxide supply is expected to be adequate for all 1950 requirements. The market price has been increased two cents a pound. There has been no change in the quality of "Solozone" DFF sodium peroxide.

Peroxide bleaching of groundwood, as well as mixtures of groundwood and sulphite pulps, is increasing in tonnage. There has been an expansion in the deinking of waste papers containing a substantial percentage of groundwood. From a technical point of view hydrogen peroxide and sodium perborate are interchangeable with sodium peroxide for the applications in the pulp and paper industry. Economic considerations govern the choice of a peroxygen compound for these uses.

ROSIN

It appears that production of rosin has been slightly smaller during the current season than was the case a year earlier, but total supplies have continued to exceed domestic consumption and export sales. However, the Government loan program prevented severe declines in price and kept price fluctuations within comparatively narrow limits. In fact, it has been interesting to note that when prices dropped appreciably below loan values more gum rosin flowed into loan stocks, while when prices advanced closer to loan values more was available for sale, thereby keeping available free stocks in close balance.

Indications are that ample supplies will be available in 1950 and the price level will undoubtedly again depend on whether loans are available on gum rosin, and the level at which loan values are set.

The trend toward the production of the paler grades of gum rosin has continued, and at times it has been difficult to find more than very small amounts of the darker grades.

CASEIN

During the first seven months of 1949, the volume of domestic casein produced exceeded the total for the same period in 1948 by approximately 45%, and supplies were readily available. With the termination of the summer "flush" season, however, domestic casein production declined sharply in favor of government-supported, non-fat, dry milk solids. Since that time, consumer requirements have been satisfied only through importation. Although ample supplies have been available in Argentina, transportation difficulties have resulted in critical, albeit temporary, shortages in this country.

Prices, which on January 1, 1949, were quoted generally in the range of 27¢ to 28¢ per pound for domestic and 25¢ to 26¢ per pound for Argentine casein, declined gradually reaching a low of about 19¢ per pound for domestic during August and $16^1/_2$¢ per pound for Argentine during September. The trend is again upward, with prime quality domestic currently quoted nominally at approximately 23¢ to 24¢ per pound and Argentine about 19¢ per pound. The consensus is prices should remain stable through the balance of the year.

Prospects for increased domestic production and corresponding lower prices during 1950 depend entirely upon the attitude of the Government with regard to dairy products price support. Should the Department of Agriculture continue to purchase non-fat, dry milk solids at prices and in volume comparable to the 1949 program, the outlook for casein is not encouraging. On the other hand, lower support prices and a restricted purchase program for non-fat milk powder would undoubtedly be reflected in increased production of lower cost casein.

ALUM

The supply and demand for commercial alum during 1949 was well balanced except for some tightness in the market during the late summer, believed to be caused by changes in inventory positions. There were no changes in the price during 1949. Demand is expected to continue at full plant capacities during 1950 and no price changes can be foreseen.

The consumption of iron-free alum during 1949 was approximately equal to production. There was a slight price advance in the early part of the year. No changes in availability, price, uses, or substitutes are expected for 1950.

SODIUM ALUMINATE

Sodium aluminate was readily available during 1949 although consumption was generally at or near plant production capacities. No changes in price or uses occurred during 1949 and no changes are expected in 1950.

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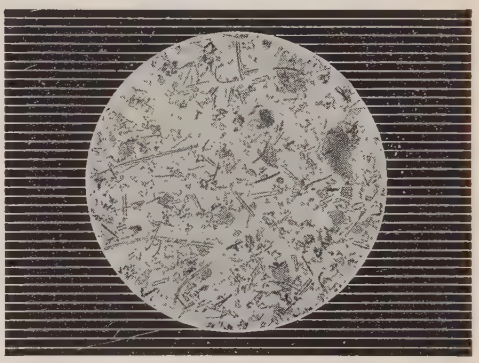

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GLUE

All types of animal glue are now in fairly free supply and demands are being met without delay.

Inventories in the hands of consumers are low and while manufacturers accumulated some inventories during the past Summer, during the general business adjustment period, stocks of Glues, held by consumers and manufacturers, are hardly adequate to be considered a "comfortable position." Any appreciable increase in demand could easily absorb any inventories accumulated by manufacturers and necessitate releasing shipments from current production. Should this materialize, it will have a tendency to slow deliveries and it is therefore recommended that users carry reasonable inventories and allow manufacturers a minimum of two weeks time within which to make shipments. Production and demand for the Fall months are just about in balance.

Labor, coal, and freight are major cost factors in the production of animal glue. Approximately 10 pounds of raw materials and 8 pounds of coal, purchased on a "point of origin" basis, are consumed in the manufacture of each pound of glue. Freight cost alone, plus "freight prepaid" on finished glue, accounts for a large percentage of the price of animal glue. It is apparent that freight, coal, and labor costs, without a break in the general economy, will continue on present or increased levels. Taking these factors into consideration and knowing that raw materials for making glues cannot be produced lower than they are at present, it is evident that animal glue prices will not be lowered and conditions might require them to be increased. The market is very stable at the present time and the industry is anxious to maintain present levels.

The demand for animal glue by the paper industry, is very good and in instances where substitutes were introduced during the war period when glue was in critically short supply, animal glue is again being used.

It appears that during 1950, conditions within the animal glue industry will continue as they are unless a major change takes place in all businesses. As far as can be approximated, taking into consideration the many industries serviced by the animal glue industry, this change is not anticipated and we expect good supplies of raw materials and a good demand for glue.

STARCH

The availability of starch exceeds demand, and a large crop production indicates further eventual decrease in price. There are no new uses, and no substitutes appear to be forth coming. It appears that the use of starch will continue to increase.

ENZYMES

Amylolytic enzymes are widely used in the industry for all types of starch applications including sizing, coating, and laminating. Such enzymes are now prepared at several standard strengths with the trend in usage being toward the new higher strength enzymes. These are usually priced somewhat lower per unit of starch converting strength.

The supply of amylolytic enzymes is ample to meet all normal demands.

DYESTUFFS

The demand for dyes has decreased considerably and adequate supplies are available. Prices have been reduced on certain dyes since the advances in December, 1948, and the first of this year. No substitutions were necessary as adequate supplies were available, and the outlook for the coming year is that there will probably be greater production of colored paper, if business holds at present levels, and dyestuffs suppliers will be able to take care of the demand.

CLAY

Productive capacity for paper machine-coating clays has increased substantially, as predicted. Although demand for these clays has continued strong, showing only very slight slackening in the early Summer, supplies have been ample and deliveries are going out on schedule.

No changes in the price of domestic coating and filler clays have come to our attention.

No application of clay to uses other than those of the past has been publicized. Supplemental pigments continue to be used in small quantities where special effects are desired, but there is no evident displacement of clay by these materials.

The domestic clay industry appears well equipped and capable of meeting any foreseeable demands that may arise within the next year. It is expected that current levels of quality will be maintained and there are strong prospects for improvement in this field.

ZINC SULPHIDE PIGMENTS

There has been a change in the lithopone situation, and it is now available in quantity for those numerous uses where a higher filler content of the paper is permissible. Also it is well adapted for use in coatings. The various other grades of zinc sulphide pigments, both technically pure zinc sulphide and those of intermediate hiding power, are still in tight supply.

In the last year there have been only slight changes in the prices of these materials, with lithopone selling for $6^1/_4$¢ per pound and zinc sulphide $13^1/_4$¢ per pound.

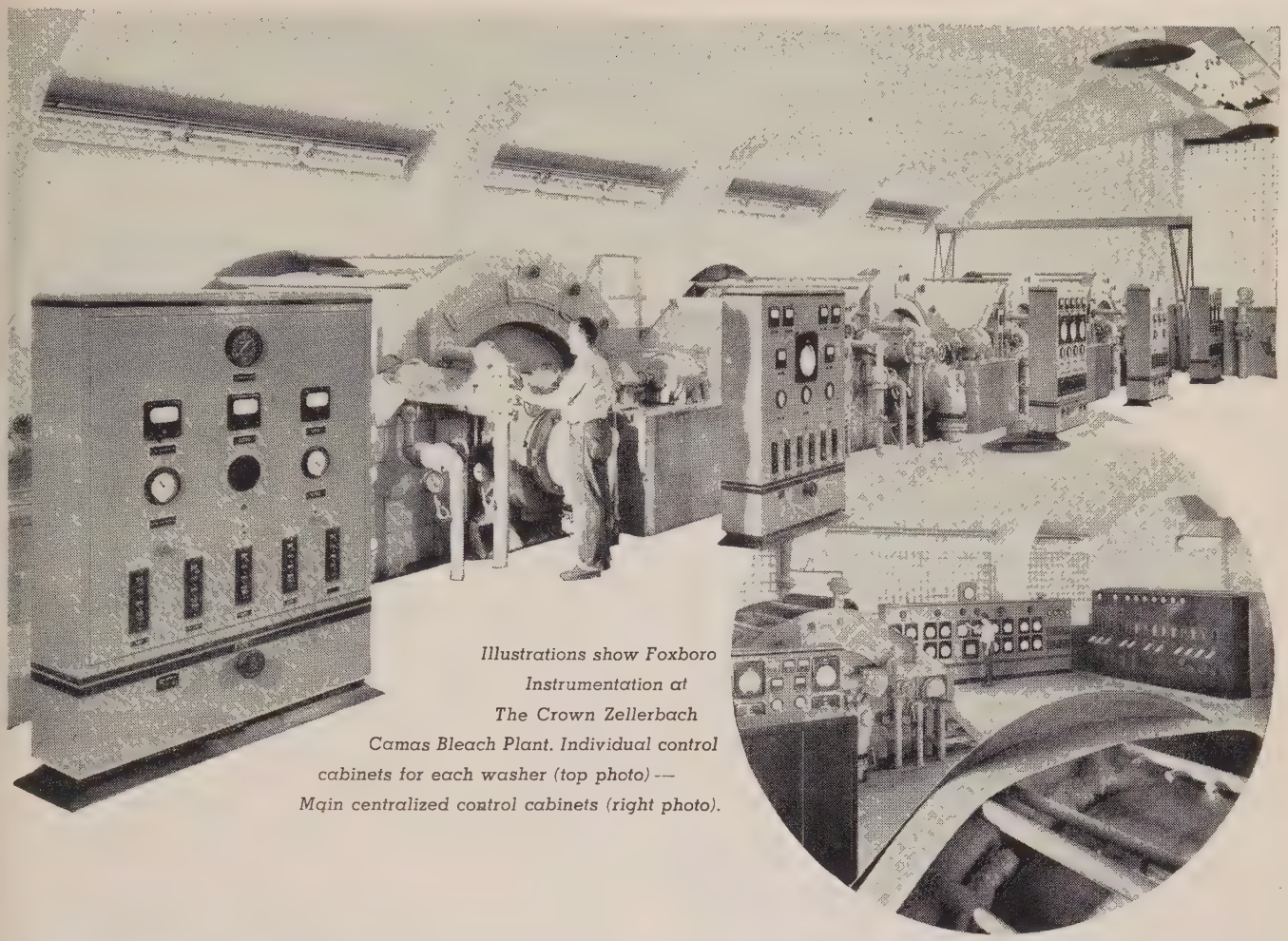
The threatened increase in mailing costs has emphasized the interest in obtaining lighter weights of paper without a sacrifice of opacity, and this has contributed to the continuing demand for these various pigments.

Inasmuch as it is well recognized that none of the commonly used fillers can compete in performance with the high strength pigments, such as the zinc sulphides, where a high degree of whiteness, brightness, and opacity is desired, the outlook for 1950 is for a continuation of the situation outlined above with the further use of these pigments dependent, to a degree, upon the Government's action on mail rates.

TITANIUM PIGMENTS

The titanium pigments are in a completely free market now, and it is believed that they will remain so for 1950.

There have been no price changes this year and none is contemplated at this time. In face of ever



Illustrations show Foxboro Instrumentation at The Crown Zellerbach Camas Bleach Plant. Individual control cabinets for each washer (top photo) — Main centralized control cabinets (right photo).

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increasing costs, the trend is more apt to be upward than downward, but conditions in 1950 will have to be the determinant of any change.

Uses for titanium pigments in the paper industry remain much the same as to types but volume is showing substantial gain. Of particular interest might be the fact that during this past year, and no doubt for 1950, a number of concerns will make use of the composite (titanium calcium) pigment in addition to the more general usage of the titanium dioxide pigment.

In conclusion, it is expected that the over-all demand for titanium pigments in the paper industry to increase substantially during 1950, but likewise producers expect to be able to fully meet this demand.

SYNTHETIC RESINS

The past year and the return to competitive markets which it brought witnessed increasing awareness by paper manufacturers of the possibility for using synthetic resins to diversify production and compete in new fields. Expanded production facilities on the part of resin manufacturers assured ample supplies of previously established resins and active development and production of new species.

In general, prices of resins for paper manufacture have been steady at current low levels.

In addition to established uses to provide wet strength in towels, bag paper, etc., synthetic resins have been employed extensively in the manufacture of twisting tissue as an aid in the twisting process. Surface effects such as improvement in dimensional stability, abrasion resistance, wet scuff, lowered pick, sizing for gloss ink hold-out, and increase in bursting strength and rigidity have all contributed to expanding use of resins in paper manufacture. There is also evidence that wet strength resins improve retention of fines in saveall operation. Finally, increased interest has been expressed in precipitating polymer emulsions on paper pulp for improvement in final characteristics such as tensile and tear strength, as well as fold endurance. It appears quite possible that this can assume commercial significance.

At present, no natural products appear likely to become substitutes for synthetic resins now used in paper manufacture. On the other hand, activity of a development nature is high. Variations of established resin species and introduction of new ones will undoubtedly continue, thus assuring the papermaker of constant effort toward improved efficiency of operation and more diverse possible effects.

It appears that 1950, in addition to witnessing expanded consumption of synthetic resins for established uses in paper manufacture, will be a promising year for fruition to commercial scale of a number of new, diversified applications in which synthetic resins play a part.

WET-STRENGTH RESINS

Currently and through 1949 the availability of both melamine and urea resins for wet-strength paper work has been ample. The consumption of wet-strength resins was lower during the first six months and through July of 1949 as compared to 1948 usage. However, starting in August and up to this date there has been a tremendous boost in the amount of wet-strength resins consumed. It is believed that the lower consumption in the first part of the year was due to both the curtailed paper production in that period and to an effort by the paper mills to work up all excess inventory. The months of August, September, and October however have shown consumptions of resins which are in excess of the corresponding months of 1948 and the balance of 1949 looks bright.

Prices on wet-strength resins remain firm during 1949, no price change are contemplated in the immediate future.

The consumption of wet-strength resin seems to be growing at a fair rate both in the increasing tonnage of current types of wet-strength papers and in a few new wet-strength papers. There are some efforts now being made to use wet-strength resins for the dry strength improvement that they give paper, and this new field will probably become even more important in the future.

Several new wet-strength resins are appearing on the market as other resin producers become interested in the wet-strength field. In general they appear to be similar to types of urea wet-strength resins already on the market and no really new process has yet been announced.

In concluding the year of 1950 will probably be a good one for the sale of wet-strength resins. A normal growth in the use of the resins is anticipated.

WAX SIZES

The availability of the wax sizes has been very good during 1949 and it is expected that everything will continue along this line for the coming year. Price changes have been narrow, but there is a definite downward trend.

The only new use to be reported is in the manufacture of slip-easy glassine. There is no comment regarding substitutes for wax, and the outlook for the production of high-quality emulsions in 1950 is very good.

PLASTICIZERS

The favorable supply position reported last year has steadily continued to improve. At the present time there is apparently no difficulty in securing adequate deliveries of any of the commonly used plasticizing agents and the general outlook is for a continuance. With one notable exception, prices are relatively unchanged from the levels prevailing during the last quarter of 1948.

Glycerin

A good balance between supply and demand is reported to exist, although some uneasiness is felt over the presently tight situation in crude glycerin. Production of synthetic glycerin is said to be at or near capacity with the full output still being absorbed under long term contracts. A substantial price reduction in March brought the cost of high-gravity glycerin to $24^{1}/_{4}¢$ in drums, carload and $24^{3}/_{4}¢$ l.c.l. These prices are still in effect and no change is anticipated for the balance of 1949.

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Invert Sugar

The present supply situation is favorable and is thought likely to continue so into 1950. A possibility of Eastern shortages exists should a longshoremen's strike develop and be prolonged. Such possible shortages would probably be largely cushioned by shipments from beet sugar areas. Prices are currently ranging from \$7.80 to \$8.30 cwt. drums, f.o.b. works, representing a slight advance over the corresponding period for 1948. These prices appear firm and are likely to remain in effect for the rest of the year.

Corn Sugar and Syrup

Corn sugar and syrup is in ample supply with future predictions favorable. Prices have shown little change during 1949. Dextrose is currently quoted at \$6.50 cwt. in bags; carload and 42° syrup (unmixed) is \$5.97 cwt. in barrels carload.

Sorbitol

A very satisfactory supply picture for sorbitol is reported, particularly with respect to the fine crystalline grades which were rather scarce in 1948. Prices are steady on the commercial grade at $23^1/_4$¢ drums, carload and at $16^1/_2$¢ drums, carload for the 70% solution.

Urea

Considerable improvement in urea over the 1948 situation is to be noted. Recent heavy purchases for export were not observed to cause unfavorable reactions on the supply for domestic consumption. Prices are firm at $4^1/_2$¢ bags, carload and 5¢ bags, l.c.l. which levels are slightly higher than in 1948.

Sodium Nitrate

Sodium nitrate has somewhat improved in supply over 1948 with optimistic predictions being made for 1950. Prices are firm at \$48.50 per ton in bags, carload for the crude, domestic, which is a little higher than 1948 levels.

BACTERICIDES AND FUNGICIDES

All raw materials, with the possible exception of steel drums, are in adequate supply. However, an adequate number of drums are still being obtained.

Prices of phenylmercuric acetate have been reduced during 1949 from \$0.40 to \$0.45 per ounce to about \$0.20 per ounce. These changes have been reflected in increased amounts of phenylmercuric acetate in some products and reduced prices for others.

While no strictly new uses have been developed during the year, there has been a steadily increasing amount of interest in microorganism control because of pressure to reduce operating costs. At the same time an effort is being made to provide the buyer with higher and more uniform quality characteristics. The demand for special characteristics, such as mold resistance, also has increased the demand for microorganism control products.

Synergistic combinations of efficient bactericides and fungicides have been developed to provide similar slime control advantages to those provided by mixtures of phenyl organomercurials and chlorinated phenols for use in the production of paper or paperboard for food packaging where the use of chlorinated phenols under some circumstances has resulted in the retention of a medicinal type odor.

The outlook for 1950 is for increased interest in microorganism control because of continued pressure to reduce production costs and buyers who demand better and more uniform quality characteristics. Prices for phenylmercuric acetate have now reached a level which is reasonable in relation to the cost of manufacture and merchandising. Further changes, if any, therefore must be insignificant compared to the decrease from \$1.20 per ounce which was the price in the years before and immediately following World War II to the current price of about \$0.20 per ounce.

CONTRIBUTORS TO REPORT

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Sulphur—D. B. Mason, Freeport Sulphur Co., N. Y.
Sulphur dioxide—W. F. Luckenbach, Virginia Smelting Co., W. Norfolk, Va.
Chlorine—R. W. Hooker, The Chlorine Institute, New York, N. Y.
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Alum-Sodium aluminate—J. P. Bainbridge, Monsanto Chemical Co., Boston, Mass.
Starch—J. P. Strasser, Stein Hall & Co., New York, N. Y.
Enzymes—F. H. Denham, R. T. Vanderbilt Co., New York, N. Y.
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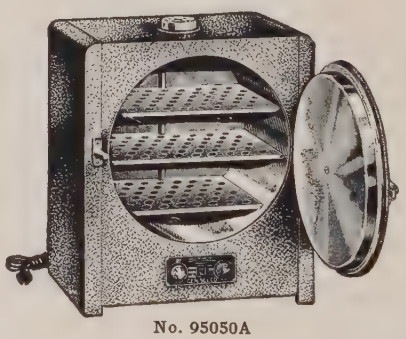

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Some Observations on the Use of Straw and Other Agricultural Residues in the European Pulp and Paper Industry

JOSEPH E. ATCHISON

In view of the limited amount of softwood available in Western Europe, the ECA has felt that extensive development of the use of hardwood, and straw and other agricultural residues could become of great importance to the pulp and paper industry in many of these countries. Fortunately, the ECA pulp and paper staff in Paris, the ECA missions in the various countries, and the Pulp and Paper Committee of OEEC—the European counterpart of ECA—all share this view and the progress being made in this development can be reported.

Because of the great interest in the use of these raw materials, the author was called upon early this year (1949) to make a survey of the present and potential utilization of hardwoods, straw, and other agricultural residues by the pulp and paper industry of Western Europe. Approximately five months were spent during the past summer visiting pulp and paper mills, research and development laboratories, pulp and paper schools, and talking with government officials, trade association officials, company executives, and operating personnel in seven countries of Western Europe. These countries were France, Italy, Germany, Holland, Belgium, Austria, and England.

Before going to Europe the author visited the Northern Regional Research Laboratory in Peoria, Ill., and had extensive discussions with E. C. Lathrop and S. I. Aronovsky regarding the developments which have taken place in the United States in the utilization of fibrous agricultural residues for the manufacture of pulp, paper, and wallboard. A summary report of these developments was distributed widely to all people who were interested in use of fibrous agricultural residues in Europe.

During the visits in Europe, emphasis was on a study of straw and hardwood utilization. However, a rather good over-all picture of the pulp and paper industry in each country was obtained.

ITALY

The use of straw for the manufacture of pulp and paper has probably reached a higher state of development in Italy than in any other country in the world. This development took place before World War II. It received great impetus under Mussolini's program of self-sufficiency during which time several modern bleached straw pulp mills were constructed with Government assistance.

An elaborate system for cutting and cleaning the straw is used by all of the mills in Italy, and variations of this system are used in all of the countries of Europe. In contrast to operations in the United States all of the European mills cut the straw before feeding it to the digesters.

At the present time, there are three pulping processes in common use in Italy for production of straw pulp. These processes are: (1) the monosulphite process in which sodium sulphite and caustic soda are used as cooking chemicals in amounts equivalent to about 10% sodium sulphite and 5% caustic soda, based on the dry weight of the straw; (2) the Pomilio process, which is a continuous process, carried out by running the straw through caustic soda and chlorine reaction towers in turn, followed by a bleaching operation; and (3) the Marsoni process involving a cold digestion of the straw with a low concentration of caustic soda for a period of 15 days.

Total capacity for production of bleached straw pulp in Italy is about 60,000 tons per year, although only about 35,000 tons were produced in 1948. This straw pulp is used in small proportions in almost all grades of paper in Italy including newsprint. In some grades of paper it is used in rather high percentages and considerable quantities of glassine and greaseproof paper are being produced from 100% straw pulp.

In addition to the bleached straw pulp, there are about 80,000 tons per year of strawboard, corrugating paper and rough wrapping paper produced from straw in Italy by a great number of extremely small family operated mills. These mills have extremely small one-cylinder machines each producing from a few hundred pounds to 2 or 3 tons per day. There are about 100 such mills in Italy, all of which are very secretive about their production statistics, operating statistics, processes used, etc. However, it is believed that most of them use the straight lime process.

Another interesting development in Italy has been the utilization of arundo donax cane for the production of high-quality rayon pulp.

WESTERN GERMANY

At the present time there are only three mills in Western Germany which produce bleached straw pulp. These mills all use the straight soda process for cooking the straw. Total production is about 20,000 tons per year. There are also several board mills which use straw for corrugating paper and other rough grades of board, but total production of these mills amounts to only about 40,000 tons per year. The lime process is used.

This situation is in direct contrast to that which existed before the war when there were 17 mills producing straw pulp of which 12 mills produced bleached pulp. This pulp was used extensively throughout the German paper industry, total production amounting to 100,000 metric tons per year. Most of these mills were in the Russian occupied areas where straw was plentiful and available to the mills at low cost.

At the present time, even though there is a large quantity of straw grown in Western Germany, it is almost all used for other purposes, and there is very little available for use by the pulp and paper industry.

NETHERLANDS

There is a greater quantity of straw used in the pulp and paper industry of the Netherlands than in any other country of Europe. The use of straw is especially important in the Netherlands because this small country has practically no pulpwood supplies, and they do have large quantities of cereal straw available.

The main use for straw, at the present time, is in the strawboard industry which constitutes the largest segment of the Netherlands pulp and paper industry. There are 19 strawboard mills in the Netherlands with a total production capacity of about 350,000 metric tons per year. However, at the time of the visit, because of lack of markets, these mills were operating at only about 50% capacity.

As a result of observations of these mills in operation, it appeared that they have not been very progressive in adoption of new methods of operation, new processes, or new items of equipment. All but four of the mills use the traditional lime cooking process and, in addition, they do not wash the pulp at all after the cooking process. Thus all of the residual lime and all of the fines in the straw remain in the pulp when it goes to the paper machines. Although this method gives a

(*continued on page 48 A*)

Presented before the annual meeting of the TAPPI Fibrous Agricultural Residues Committee, Terre Haute House, Terre Haute, Ind., November 7–8, 1949.

Joseph E. Atchison, Member TAPPI; Chief, Pulp and Paper Section, Forest Products Branch, Economic Cooperation Administration, Washington, D. C.

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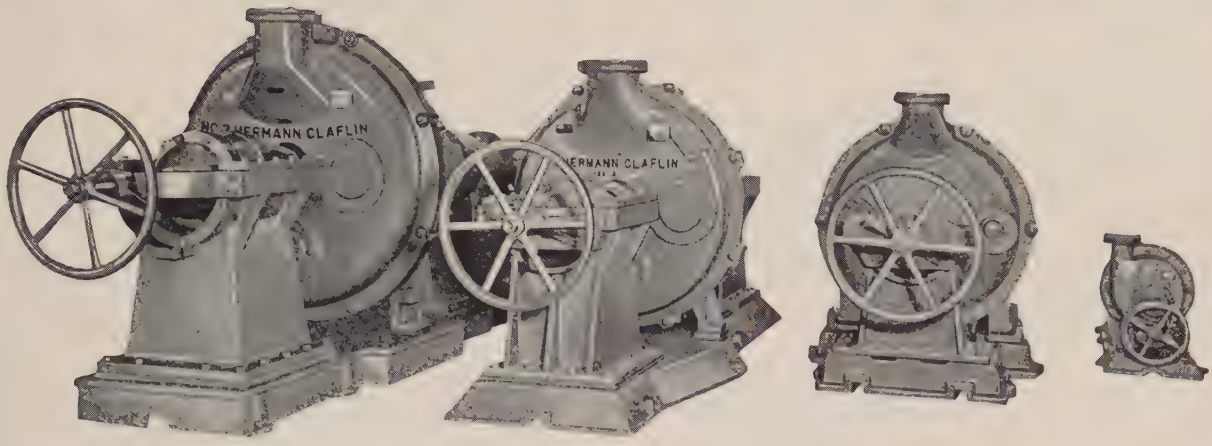

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high yield of 75 to 80%, it also results in a low-quality product for use in corrugated and solid fiber boxes.

Only four of the existing mills have taken steps to improve their product by using other cooking processes. These mills use either the soda process or the neutral sulphite process. Both of these processes result in a pulp which is superior in quality to that produced by the lime cook, although both result in higher cost.

When visiting these mills, many phases of their operations were noted which could be improved greatly. It appeared that definite steps will have to be taken to improve both their methods of operation and the quality of their product if they are to continue to exist.

At the present time there is only one mill in Holland which is producing bleached straw pulp. This mill produces about 18,000 tons of bleached straw pulp per year, all of which is sold to other companies. It uses the monosulphite process.

Plans are under way to increase the production of bleached straw pulp in the Netherlands and this seems to be a logical development.

Another important use for straw in the Netherlands is for production of wall board. One mill which went into operation in 1948 produces both insulating board and hard board from straw. It uses the Asplund defibrator process for cooking the straw. Although this mill has experienced many operating difficulties, it was in full production at the time of the visit and an excellent quality board was being produced.

A considerable amount of research and development work is going on in Holland on the utilization of straw. The principal organization in this field is the Netherlands Experimental Station for Utilization of Straw which is financed jointly by the Government and industry. They have carried out some very important work including the basic work for the establishment of the wall board industry. Many other important projects are in progress, and the staff is highly enthusiastic regarding the future utilization of straw.

BELGIUM

The utilization of straw for the production of pulp and paper in Belgium is confined to the production of low-quality strawboard. At the time it was visited, there were four such mills in operation with total production of about 15,000 tons of strawboard per year. The equipment in these mills is very old and obsolete, and production methods have not been improved for fifty years.

The cost of production of strawboard in these mills is twice the cost of production of the same grade of board in the Netherlands and the strawboard mills in the Netherlands are far from being modern. Until recently, the Netherlands Strawboard Association had agreed not to sell their board in Belgium at prices lower than the Belgian board producers could meet. However, with the formation of Benelux coming more and more into being, the Netherlands mills have now started selling their board in Belgium at prices as low as $50 per metric ton. Belgian producers claim that their costs of production amount to almost $100 per ton. Thus, it appears likely that the Belgian strawboard mills will either be forced to modernize their operation or suspend operations in this field in face of the competition from the Netherlands mills.

The strawboard is converted into corrugated and solid fiber boxes for use as shipping containers. To improve the appearance and strength of the boxes, various grades of paper are laminated to the strawboard. Thus, by using various combinations of different types of paper with the strawboard a great variety of types of boxes are produced.

FRANCE

It was surprising to learn that the use of straw in the French pulp and paper industry has been confined mainly to the production of strawboard, corrugating paper, and rough-quality wrapping paper. In addition, most of increased use of straw contemplated for the future is for corrugated boxes and not for high-grade paper.

At the time of the visits in France, there were actually only four mills producing bleached straw pulp, and all of these were producing on a small scale and for their own use; total production being about 3000 tons per year. However, at least six companies have indicated their intention to build facilities in the future for production of bleached straw pulp in sizable quantities. These companies have been studying the relative merits of the processes now being used in other countries. Some of them favor the Pomilio-Celdecor process and others favor the monosulphite process as offering the greatest advantage under the conditions prevailing at their respective mill locations.

There are 19 mills producing about 25,000 metric tons per year of unbleached straw pulp. This is used in combination with waste paper or wood pulp for low-quality wrapping paper.

There are also a great number of small mills, each producing small quantities of strawboard and straw corrugating paper by the lime process. Total production of this grade of material amounts to about 80,000 tons per year.

One interesting process in use in France is the Huguenot process for production of unbleached straw pulp for corrugating paper and rough grades of wrapping paper. This process is a continuous caustic soda process which makes use of agitation in the reaction tower to speed the reaction. It has been rather successful.

A limited amount of bleached esparto pulp is also produced in France and small amounts of pulp have been produced from arundo donax cane.

In view of the extreme shortage of softwood pulpwood in France and its dependence on imports to supply existing pulp mills, it is believed that there will be extensive developments in the use of straw by the pulp and paper industry of France in the future.

AUSTRIA

Straw is not used at all in the pulp and paper industry in Austria because there are no supplies of straw available from domestic sources and pulpwood is comparatively plentiful.

UNITED KINGDOM

Esparto grass, which is imported from North Africa, has been a traditional raw material for production of high-quality bleached pulp for high-grade papers in the United Kingdom. Previous to the war the esparto mills produced 150,000 tons of bleached pulp. Although the supply of esparto was cut off during the war, it has now been resumed and prewar production levels are being reached.

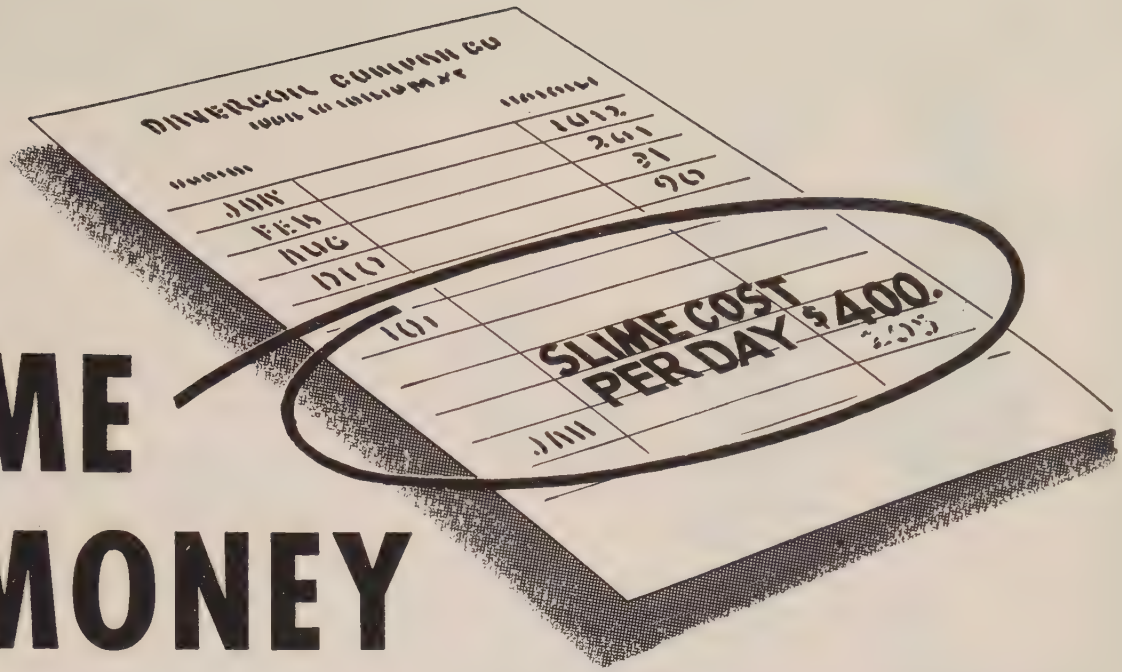
Esparto grass is extremely expensive, thus the cost of the pulp is very high. It is justified on the grounds that extremely high-quality papers can be produced from this pulp which bring a high price on both the domestic and export market.

All of the esparto mills use the conventional soda process and they are all extremely old. It is doubtful if any new esparto mills have been installed in the past 50 years.

Before the war, there was practically no straw used for production of pulp and paper in the United Kingdom. However, when supplies of esparto grass were cut off from North Africa, it became necessary for the esparto pulp mills to seek another source of raw material. Thus the esparto mills turned to straw and its use increased until 120,000 tons of bleached straw pulp per year were being produced.

Because of the great difference between esparto and straw,

(*continued on page 50 A*)



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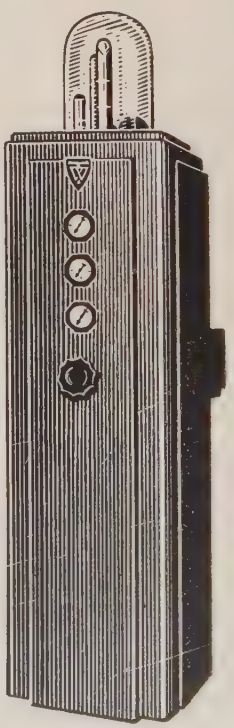

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Butterworth Calender Rolls

the esparto mills experienced many difficulties in converting from esparto to straw. All of these mills had soda pulping equipment with stationery vertical digesters specifically designed for esparto and this equipment was not suitable for economic production of straw pulp. However, by gradually modifying their process, they were eventually able to produce a suitable pulp. The pulp, of course, was never as good as could have been produced in equipment and by a process specifically designed for straw pulping.

Because of the difficulties involved with their antiquated equipment and because of their traditional use of esparto, almost all of the mills converted back to the use of esparto after the war when it again became available. The use of straw decreased rapidly and during 1949 only about 35,000 tons of straw semipulp and bleached straw pulp are being produced.

This does not mean, however, that there is no interest in use of straw in the U. K. On the contrary, there are numerous developments under way to bring about an increased use of straw. Some of the large companies, such as Bowater's have concluded that on the long range basis, straw has a very definite place in the pulp and paper industry of the U. K., and they are proceeding with construction of mills for this purpose.

Most of the companies using straw or who contemplate its use are using some part of the Celdecor-Pomilio process developed by the Cellulose Development Corporation. This company has obtained the world patent rights to the Pomilio continuous process. They also have the Max Grumbach patents for production of straw preparation equipment. Thus they are able to furnish complete equipment for straw pulp mills. For many years the company has specialized in the development of equipment and processes for the production of bleached pulp from straw and other agricultural residues. They have a complete small scale plant which is used as a pilot plant for continuous production of 3 metric tons of high-quality bleached straw pulp per day. This plant has been used as a research installation for developing straw pulping processes on a practical scale, and the pulp produced is used in fine papers by an adjoining paper mill. In addition, the company has had experience in 20 full scale plants in various parts of the world in which agricultural residues are being used. As a result of this background of experience, they are extremely enthusiastic about the possibilities of greatly increased use of straw in the future.

That rather sketchily covers the use of straw in the European countries which were visited.

In view of the developments in progress and those which the author has heard of in other parts of the world, he feels certain that there will be greatly expanded use of both hardwoods and agricultural residues for the production of pulp and paper in the next few years. Successful use of these abundant materials will go far toward easing the fear of a world-wide shortage of fibrous raw material for the pulp and paper industry.

It is the intention of the Pulp and Paper Section of ECA to promote these important developments in Europe in every way possible. Encouraging progress is already being made in this direction.

Before closing, one other highly significant development which ECA has been promoting and encouraging should be mentioned. That is the establishment of a technical association of the pulp and paper industry of all of Western Europe. All will probably agree that this is a worthy project. One has only to think of the outstanding contributions which TAPPI has made to the pulp and paper industry of the United States to visualize the possibilities of a similar organization covering the entire pulp and paper industry of Western Europe. It is only by such cooperative efforts that the pulp and paper industry, one of the largest and most vital of European industries, can take its rightful place in the over-all recovery of Europe.

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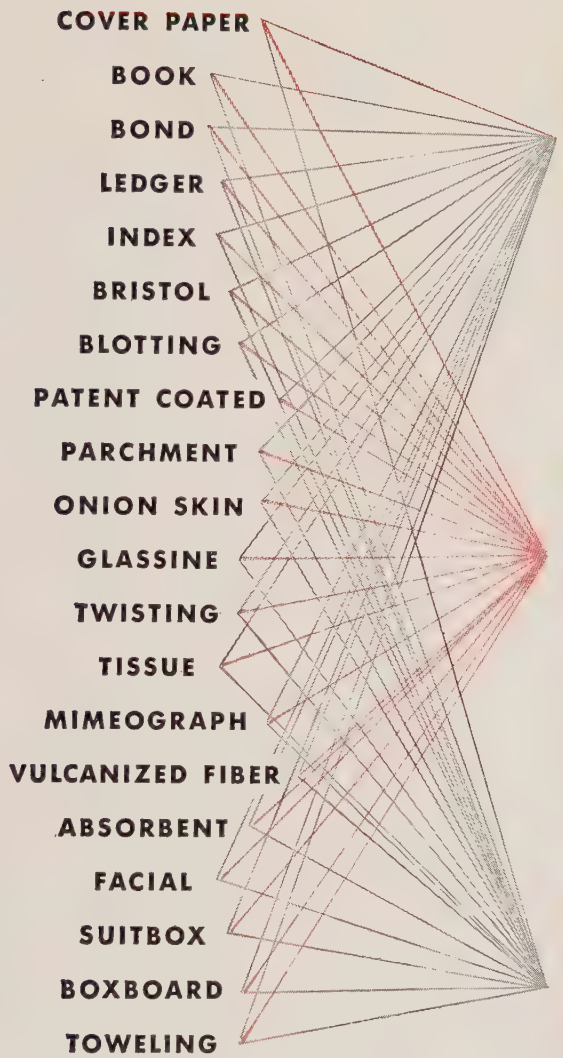

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Modern Paper Mill Buildings

M. C. CELLI

The best contemporary design of all the component parts of paper mill buildings uses "fitness for purpose" as a common denominator. The processes of equipment operation and building design are inseparable and indispensable. Paper mill building cost 20 to 25% of the total project cost. Today they are no longer simple enclosures of space—in order to develop the utmost potential in production, they must provide the best physical environment for each machine and for each individual. An examination of the components to the design of buildings must provide this environment—the structural frame, the walls, the roof, the acoustics, the lighting, the use of color, and the internal atmosphere. There is new emphasis on better employee facilities. An analysis is given of floors and the floor drainage problems with remarks on the corrosion of concrete and masonry caused by fumes and solutions. A study of a semiopen recovery building is presented. Suggestions are made for saving some maintenance costs on buildings with plates detailing eight typical wall sections and eight roof sections, together with a structural and functional analysis of each.

FORTUNE magazine in a recent issue illustrated some modern factories under the title, "The Beautiful Factories." It explained the dramatic changes in the American industrial landscape since the war, and then the article made a startling statement—one which could not have been accepted a few years ago, "The better they work, the better they look." Let us examine this statement.

Modern industry is a powerful force on social welfare. Its factories are the shelter of thousands of human beings during the most active hours of the day and as such can exert tremendous power for good. The architecture of industry which must do its great share to see that this power for good is fulfilled has every opportunity to acquire a quality of greatness. The hard realities of producing and manufacturing on today's vast scale certainly guide architecture toward honesty, and a new beauty fashioned by technical excellence, scientific knowledge, and disciplined vision. The realities of industry insist upon a design which is fit for the purpose; which aims at relating methods of building to real needs, and to a design which will result in a sensible job of building. Industry recognizes that the factory today, as always before, is the backbone of the community. This is especially true for the paper industry, since many pulp and paper plants are developed in the most isolated locations. In the past, buildings were conceived as simple enclosures of space, shutting out the weather, with provisions for minor utility services but not much else. Buildings today, in order to develop the utmost potential in production, must incorporate the proper techniques and materials to produce efficiently the best environment for each machine and for each individual.

M. C. CELLI, The Rust Engineering Co., Pittsburgh, Pa.

PAPER MILL BUILDINGS

Modern paper mill buildings are fashioned by the scientific use of imagination. The common denominator of this architecture is a design of strong clean lines highlighting the functional attributes. Disciplined simplicity and rhythmic repetition are the keynotes in the new design whether the construction is for one building or for an entire plant. It is an architecture of economics where economies take precedence over esthetics and where form really follows function. This work is not glamorous. It is hard, sometimes dry. It is subject to many revisions as the equipment design is being developed, and most important, there are costs to be met and justified. The buildings demonstrate the hand of the production engineer as well as that of the architect; the economy makes for character, and the finished product is a severely unadorned process building which is fit for its purpose, works better, and looks better.

In speaking of paper mill buildings, a very sizable percentage of cost of a paper mill project is being considered. Generally, the building value is 20 to 25% of the total project value, not including the site. Faced with such an expenditure of money and with such complicated design, we must coordinate an intelligent team of technicians whose combined knowledge and experience supplies the factual basic approach to building.

Moreover, the requirement to produce efficiently and control precisely the best physical environment for each machine and for each individual is altering the entire approach to the design of buildings.

Let us then examine some of the components of the design of the building as an enclosure of space. First to be considered is the structural frame with its walls, roof and floor; second, its acoustics; third, its lighting; fourth, the use of color; and last, the internal atmosphere.

The Building Shell

The first component is the building shell which is no longer a simple barrier against undesirable weather. It must welcome all the pleasant elements of the atmosphere and exclude the undesirable. The inside environment as well as the outside environment influences the design of the shell. Industry is developing more and more of the skin type of curtain walls as simple veneers, using factory-rolled steel sections, or precast concrete and insulation sections, or other surfaces, rather than thick masonry walls. Of special importance, because of the high humidity and temperature conditions within a paper plant, is the proper use of vapor barriers within the walls and roof construction. All know that masonry walls will retain great quantities of heat absorbed from the sun. This heat is released later in the day when the surrounding

temperatures have fallen. In a single-shift operation, or in office buildings, this property of masonry is not too harmful. In a three-shift operation, however, during the summer, the night-shift crew working close to a masonry wall, will notice an undesirable radiant heat coming from it. There are several other disadvantages of masonry walls. The first is that condensation will occur on the porous masonry surfaces in humid climates which are subject to quick temperature changes; the second is that without adequate provision a driving rain will penetrate an 8-inch masonry wall. For use in masonry walls, where they are required, 5 by 12-inch face structural tile is quite satisfactory for interior surfaces. This is load-bearing tile available in all thicknesses, many colors, shapes, and finishes. It is the equivalent of three bricks, is laid more quickly, has a more impervious surface, has more light reflectance value, is more cheerful in color, is cleaner due to fewer joints, has better insulating qualities, and is cheaper laid in place. For such rooms as the finishing department, storage areas, basement of paper machine room, etc., the unglazed face is suitable. For walls which are subject to fumes, dust, and vapor, either salt-glazed at about 18 cents a square foot more than unglazed, or ceramic-glazed at about 26 cents a square foot more, should be used—here there is substantial saving in maintenance cleaning since no painting is necessary and a wet cloth will clean the surface perfectly. The glaze is resistant to all normal conditions in sulphate and sulphite mills. Please note that ceramic-glazed tiles, available in many field colors, are only 8 cents more a square foot than the cream-colored salt-glazed tiles. This is much cheaper than painting for color harmony effects. Moreover, the reflective quality of the glazed surface will materially help retain heat rays within the building in winter.

Windows should be used only where there is a positive need for ventilation or natural daylight to increase the cheerfulness of a room. The function of a window for working light is considered to be very secondary since it is subject to the whims of the sun and weather, and cannot be controlled. Very little sash is being used today—it is an expensive maintenance item, and there are very few places in the process rooms of a modern paper mill where its use can be justified. Where controlled ventilation is not required by the process, protected metal or aluminum louvers are used to obtain fair control of natural ventilation. The thermal performance of single-thickness glass is very poor and the use of double-glazed units for extensive areas is very expensive, as is the use of heat-absorbing or glare-reducing glass. Another problem encountered through the use of extensive areas of sash is the glare produced by contrast of bright glass surface against the darker wall surface. This deep contrast is a source of eye fatigue. Another disadvantage is the loss of artificial light which filters out through windows at night.

Glass blocks or corrugated glass set in rust-resistant channels have been used where light is necessary. For vision, double-glazed plate glass panels placed just at eye level at convenient areas in the floor layout are used. These vision panels have an important function in permitting a change in focus of eyesight, relieving eye fatigue. The use of this fenestration (which incidentally can be blacked out very easily if the need should arise) can result in long lines with wall surfaces that are strong, simple, well proportioned and relying on mass, texture, and color for their effect. High parapets should be eliminated everywhere except at fire walls where the underwriters may require them; they are a source of leaks and an unnecessary maintenance problem. If the glass blocks are set in aluminum or lead-coated channels and the vision panel frames are of rust-resistant metal, there is no need for any painting whatever on the exterior other than on the main entrance doors on the ground floor.

The various paper mill buildings all have different internal design features and sizes. In order to avoid a conglomeration of shapes and to have some harmony in design so that the group of buildings is tied together, a strong design feature should be selected. To accomplish this a base course of cream-colored brick, in harmony with a field of red brick, was used in one plant, and in another, a continuous strip of glass blocks was located just underneath the paper machine operating floor and carried through the other buildings at that level.

Floors

The author has visited many mills and practically all of them have a floor problem. Under the digester blow valves, under the blow tank, under the knotters, under the washers, in the screen room, around the machine's wet end, around the dissolving tanks, around the cascade evaporators, around pumps—all these floors need special attention. The first preventive measure is a reasonable floor slope for adequate drainage. We have found that $^1/_4$ inch to the foot is not enough because, since craftmanship was not always perfect, the $^1/_4$ inch often became $^1/_8$ of an inch or less. Three-eighths of an inch to the foot should be the minimum floor slope anywhere in the paper mill where the concrete floor is subject to frequent hosing. All working areas and passageways should be at the high point of the slope. The slope presents a problem of raising or lowering the structural steel floor beams to maintain an equal distance from the finished floor. Generally, where the floor slope design cannot be determined until the final equipment and pump layouts are made, it is more expeditious to keep the tops of the beams level and absorb the slope in the concrete slab design. Where the equipment design is definite before design and fabrication of structural steel, then the floor beams should be adjusted to the slope. The top finish on all wet locations should have a float finish, not a steel-troweled finish, to prevent slippage.

Individual floor drains should be used only in dry areas subject to a minimum of hosing. Concrete curbs, poured integral with the slab, can be used at all wall junctions—a little item which is not expensive, but quite desirable. The author has seen many walls streaked with black liquor that has leaked from upper floors through construction cracks between walls and floors.

Another point of drainage concerns roof conductors. Rarely can these be carried straight down from the roof drain. Generally, they interfere with trusses, or else the drain is in the middle of a panel requiring long,

flat runs of conductor pipe. This is to be avoided because these sections will clog up with fly ash.

Acoustical Treatment

The author wishes more could be done with the second item of environmental study—sonic control within the average paper mill. It seems inexcusable today that so little has been done toward reducing some noises to an acceptable level. There is quite a difference of opinion on the effect that noise has on the individual. However, it has been established that noise causes irritability and disturbs the general nervous system. The ear apparently was not designed to tolerate noise for long periods of time. Localized acoustical treatment may be obtained through the application of sound absorption material in the walls and ceiling at parts of the paper machine and at the jordans. One machine builder has redesigned the suction rolls to help eliminate the noise. Several mills have pioneered and have tried acoustical treatment on the ceiling of the paper machine room. There is a lot more work, however, still to be done by the industry to correct noises.

Lighting

The third consideration in the control of conditions within buildings is lighting. The eye, like the ear, has limited adaptabilities. Any extension beyond these limits abuses the eye and disturbs personal emotions. We have become aware recently that "seeing" is more than just "foot candles," and accordingly, the technique in handling artificial lighting has undergone much development. The most important fundamental of satisfactory lighting for production is that the actual work should be the brightest object in the line of vision. The foot lambert, which is a measure of reflected brightness, must be examined along with the foot candle which is the measure of light from its source, in order to decide proper lighting technique. It has been found that contrast in brightness is very desirable for certain work conditions close to the eyes, especially for small individual tasks. Brightness contrasts of sharp distinction in large room areas, however, should be avoided since they provide distraction and tend toward eye fatigue. There is no doubt that most plants have useless and annoying contrast in surface brightness combinations. Just at present some lighting engineers are questioning the extremes of intensities to which other experts have gone, but in general, recommendations for lighting intensities have been increased. Particular study is also being made of location of light and its control by means of lens or filters. Effective lighting can be done economically by delivering the light on the work. In the rooms having large windows and three-shift operation, control should be provided on interior lighting to provide uniform working intensities on all shifts. Fluorescent lighting is being improved, but it still has many limitations on use and mounting heights. In the paper machine room a combination of mercury and incandescent provides excellent general illumination. By the use of improved vision, modern industrial operations will benefit through increased production, fewer errors, and less accidents.

Use of Color

The fourth main heading in the study of the paper mill worker's physical environment is the use of color. We have become conscious of the functional employment of color. Color is a sensation much the same as noise. It affects the general equilibrium of the body. Where the relationship among colors is pleasing, the worker is happy, the mental attitude is relaxed and cheerful. Where color harmonies are displeasing, they can create irritation and disturb personal feelings. The work of Egbert Jacobson, Director of Container Corporation's Department of Design, in the field of color is particularly to be recommended. It is mandatory today that we make extensive use of color to produce the correct environment desired at each location. Color is selected to eliminate visual clutter, to alter effect of room proportions, to reflect or absorb light, to create high or low brightness contrasts, and to lessen eye strain. Each case is judged on its own merits and the selection of color is made through the use of color harmony charts which select color scientifically by use of rhythmic ratios, rather than by the eye alone. Here, too, the old argument about the artistic versus the practical can no longer be used. The better the color functions, the better it looks.

Atmosphere

The fifth item in the study of controlled conditions is the treatment of the atmosphere within the various rooms. There is a definite trend toward placing more and more of the various departments of the pulp and paper mill under one building shell. The point to question here is the interchange of various undesirable atmospheres between departments. The air should be kept clean in the paper machine room, the bleachery, and a few other rooms. In all rooms there should be a sufficient number of air changes to carry off the various body and environmental odors and exhausts. Spot control of atmosphere is necessary for specific uses over washers, drier sections, etc. Soon air will be purified through the use of either ultraviolet radiation or germicidal vapors. Work is being done on glycol air purifying equipment and amazing results have been reported so far.

Corrosion Prevention in Masonry

There is a subject which is being investigated now—one which the author believes has not been given the attention it deserves. It is the prevention of corrosion in masonry and concrete work caused by chemical fumes, solutions, and powders, such as black liquor, salt cake, soda ash, etc. The various paint and prepared coating manufacturers have solved many of the acid and alkali problems on steel work, but a few troublesome conditions in masonry and concrete work deserve special mention. On all floors subject to severe attack by alkaline solutions or dust, the use of a separate 1-inch thick cement finish coat made with a carefully prepared and cured mix of silica sand and a good aggregate such as trap rock; or a 1-inch thick bituminous finish of a hot mix rolled or tamped down; or a large size quarry tile laid in alkali-resistant mortar is to be considered. Some may avoid the use of a separate top finish by using sulphate-resisting cement A.S.T.M., type V, in a monolithic finish concrete slab,

in place of the ordinary type I cement. So far as is known, this type V cement is made in the United States at present only by Permanente Corporation in California. The basic price is the same as other cements, but there is so little demand for it that other manufacturers have not been interested in producing it.

The same attention to finish and mix should be given to trenches draining these areas. The use of this sulphate-resisting cement on the basement and the cascade evaporator floors of a recovery building in a sulphate mill in the South added just 10 cents a square foot, although the cement costs $3.45 a barrel base price and $3.47 a barrel for freight. The strength of this concrete is very slightly under ordinary cement, but not enough to change any calculations. For the masonry wall on this recovery building, an alkali-resistant mortar composed of 1 part of this type V cement, 3 parts of good hard sand, and 4 ounces per bag of cement of a calcium or ammonium stearate powder, as a plasticizing and waterproofing agent were used. For over-all alkaline or acid fume and vapor conditions it is suggested that concrete slabs be haunched down to bottom flanges of steel beams. The form costs rise because of this and more concrete is used, but maintenance painting of steel is reduced to bottom flange only. In operating floors of washer rooms and bleachery, 9 by 9 inch quarry tile with non-slip surface laid in proper mortar may be used. This is a good floor, maintenance-free, and easy to keep clean. On concrete-faced stair treads, ramps, etc., a sprinkling of $^1/_4$-pound abrasive aggregate to a square foot will prevent slipping.

The author should like to mention the use of expansion joints to prevent damage caused by thermal movement on account of either the slow seasonal changes, or the relatively rapid fluctuations which take place within several hours. Roofs expand considerably more than side walls since they get much hotter. The painting of roof surfaces with some light color in order to provide heat reflectance has sometimes been recommended. Generally, however, each building should be checked for expansion joints if it exceeds 250 feet in length, or if it is a long wing against another building, or if it is a long low building adjoining a high rigid building.

Exterior Landscaping

The author would like to mention one small feature. Have you noticed how cheerful a clear strong moonlight can be? Since paper mill operations are on a 24-hour basis, why not help the night crews by softly floodlighting the grounds at night or at least the areas under windows used for vision panes? And if it is possible, have shrubbery and grass visible from the work areas. Due to the tremendous increase in air travel, it is becoming more important that the day and night air view of factories be taken into consideration. A soft highlight on the edges of buildings, etc. will create an outline of form visible from the air at night. Many owners are convinced that landscaping pays. There are many spots around the factory where pin oaks, ailanthus, American hawthorne, privet hedge, grass, or such trees and shrubs that are indigenous to the soil can be made to grow with a little attention. These, with some walks, some paving and a carefully designed parking lot will do wonders to make the plant look more pleasing.

Facilities for Personnel

Throughout this paper the author has been stressing possible savings in maintenance costs—sometimes through the expenditure of some additional capital. If you will investigate these extra amounts spent versus the man days saved, in most cases you will find a remarkable return on the investment. The expenditure of $33,000 is generally considered to be justified if one day worker is eliminated, or the expenditure of $100,000 for the omission of a shift job. In many instances, parallel expansion programs can be carried out in some departments without the addition of a single shift worker if proper attention is given to helping the operators of the existing facilities by relieving them of small burdens which become unneces-

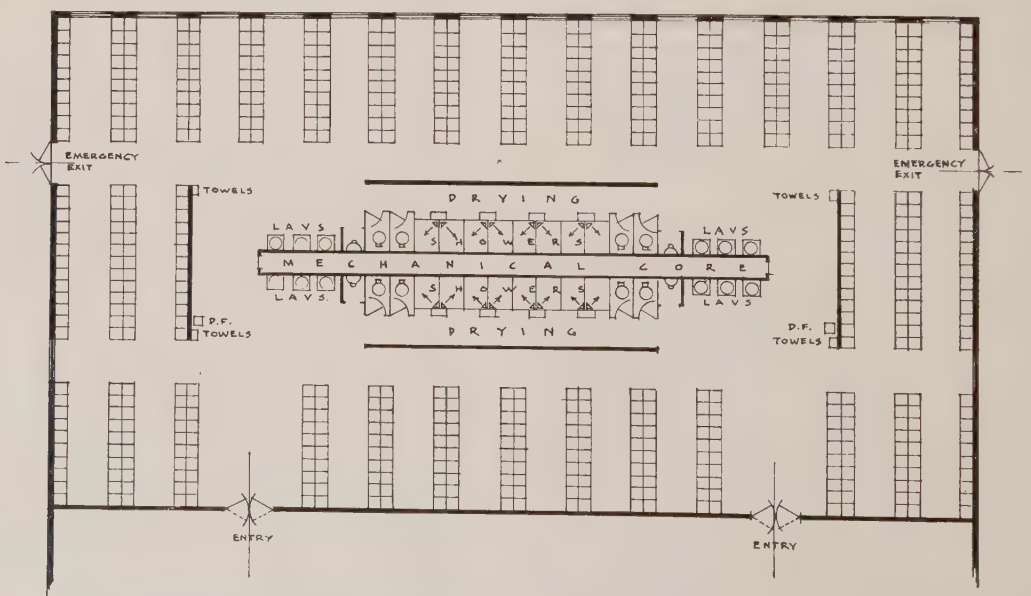

Fig. 1. Basic plan of locker and toilet room with mechanical core arranged for shift operations

WALL CONSTRUCTION CONSIDERATIONS

WALL ONLY SASH & STRUCTURAL FRAME NOT CONSIDERED

	MATERIAL		WEIGHT PER SQ. FT.	TOTAL "U" FACTOR	WALL THICKNESS	HEIGHT 30# WIND	FIRE RESISTANCE	LOAD BEARING	SOUND ABSORPTION VALUE	SALVAGE	MAINTENANCE	GENERAL REMARKS
1	4" SOLID BRICK & 4" UNGLAZED TILE		75#	.45	8"	14'-0"	4 HR.	250 P.S.I.	POOR	POOR	INTERIOR WASHING	CHEERFUL APPEARANCE CHEMICALLY RESISTANT SALT AND CERAMIC GLAZES AVAILABLE. GOOD LIGHT REFLECTIVE QUALITY.
2	INSULATED 4" SOLID BRICK & 4" UNGLAZED TILE		77#	.14	10"	10'-0" TO 12'-0"		NON	POOR	POOR	INTERIOR WASHING	
3	8" CINDER BLOCK GUNITE BOTH SIDES		72#	.40	9¼"				POOR TO FAIR	POOR	NEED FREQUENT EXPANSION JOINTS	STILL EXPERIMENTAL WITHOUT MORTAR BED. USE INTEGRAL WATERPROOFING ON OUTSIDE COAT.
4	7" CONCRETE VENEER		84#	.75	7"	UP TO 50'-0"	4 HR.	500 P.S.I.	POOR TO FAIR	NONE	NEED FREQUENT EXPANSION JOINTS	CAN BE ADAPTED TO SLIDING FORM CONSTRUCTION NEEDS. PAINT WITH WATERPROOFING.
5	PRECAST CONC. PANEL WITH INSULATING CORE		50#	.14	6"	12'-0"	3½-4 HR.	NON	POOR TO FAIR	GOOD	NONE	RELATIVELY NEW CONSTRUCTION 3 YRS. ACTUAL FIELD USE.
6	CORRUGATED GALVANIZED STEEL		3#	1.50	22 GA.	5'-0"	NON COMBUS TIBLE	NON	POOR	GOOD	PAINTING	GIRTS NECESSARY
6	CORRUGATED PROTECTED METAL		3.5#	1.50	22 GA.	5'-0"	NON COMBUS TIBLE	NON	POOR	GOOD	NONE PAINTING OF GIRTS	AVAILABLE IN BLACK, MAROON OR ALUMINUM FINISH. GIRTS NECESSARY
6	CORRUGATED ALUMINUM		0.56#		.032"	5'-0"	NON COMBUS TIBLE	NON	POOR	GOOD	NONE PAINTING OF GIRTS	GIRTS NECESSARY
6	CORRUGATED ASBESTOS		4.5#	1.01	3/8"	5'-0"	NON COMBUS TIBLE	NON	POOR TO FAIR	FAIR	LOW PAINTING OF GIRTS	GIRTS NECESSARY BRITTLE
7	PREFABRICATED INSULATED CELLULAR PANELS		12.3#	.14 TO .18	3"	10'-0" OR 18 GA.	2 HR.	NON	POOR	GOOD	MAY REQUIRE PAINT	AVAILABLE IN COMBINATIONS OF FLUTED OR FLAT ALUMINUM, STAINLESS STEEL OR PROTECTED METAL UNITS EITHER INTERIOR OR EXTERIOR.

Fig. 2

sary through the addition of automatic controls, valves, and working points in more accessible locations, and more satisfactory working conditions. The addition of elevators in recovery building additions or of escalators in other places or the centralization of instrument panels so that the operator can be placed where he is most efficient, are all examples of possible labor saving.

All branches of industry today are following an entirely different attitude toward the worker than before the war. There is a new emphasis on the human side with provision for far, far better than adequate employee facilities of all kinds. Having learned the high cost of labor turnover through bitter experience, management now realizes that the best workers are contented workers, and that expenditures to improve working conditions are well justified. At two plants which the author's company has recently built, employee facilities were provided at the entrance to the plant. These house the watchman, the timeclocks, the locker and sanitary facilities, first aid rooms, the personnel manager's office, and also include a large conference room and large waiting rooms. The psychological impact which the worker receives upon his entry to the plant must affect him either consciously or subconsciously. These buildings are low, cheerful buildings designed to provide the worker with a pleasing introduction to his day's work. The parking lot is directly outside these buildings and canopies permit an automobile to discharge its passengers under cover and then the workers may walk to the main circulation aisles of the process buildings mostly under cover. The personnel manager's office is designed to be inviting, and so placed that all workers pass in front. The large conference room housing up to 80 which is used by both management and the workers for educational, safety, or union meetings, has built-in provisions for movies. The offices are air-conditioned and the conference room, in addition, has a separate unit, with an electrical precipitator, of sufficient capacity to exhaust smoke readily. These buildings have radiant heating. Not only in these separate facilities, but elsewhere throughout the plant, the worker's viewpoint and his welfare are considered.

Figure 1 is a floor plan of a locker room which is presented as an ideal arrangement of sanitary facilities and lockers. Basically, it is the plan used at the Container Corporation of America's Fernandina plant and at Crossett Paper Mills. The center of this locker room is the sanitary core consisting of a 3 foot wide double-partitioned plumbing access well which houses all the pipes, drains, valves, fixture hangers, etc. Attached to the walls of this core are all of the sanitary fixtures, the lavatories, the urinals, the water closets, and the showers, the number divided into four sections so that each quarter area of the locker room has access to one fourth of all types of fixtures. It reduces circulation to a minimum—there is no cross flow. In

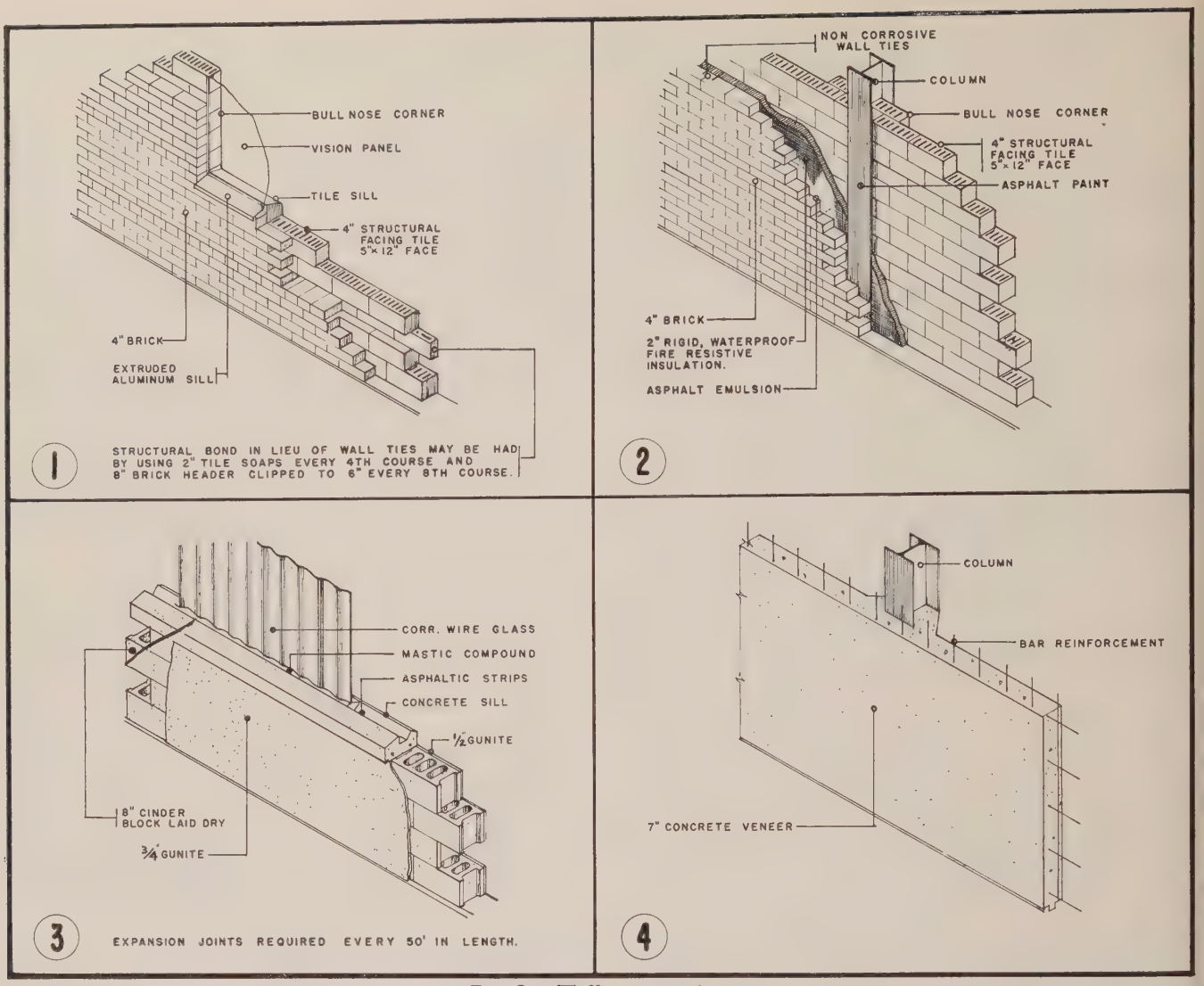

Fig. 3. Wall construction

addition to distributing the fixtures evenly, this scheme is notably economical since all plumbing work is grouped so that a single vent and a single drain has the maximum fixtures hooked to it. Moreover, all odors and vapors are concentrated so that, through louvers spaced properly on the walls, and with the partitioned core acting as a plenum, it is possible to exhaust the fixture area adequately with a single exhaust fan. Since this core contains all fixtures having water or vapor conditions, it is recommended that this wall be made of glazed tile for ease in cleaning. There is almost no other exposed wall surface since the lockers themselves act as walls elsewhere. All fixtures are wall hung, and the toilet partitions are hung from the ceiling, so that the floor is kept unobstructed and sanitary. At the ends of corridors, from base to ceiling and for the full width of the aisle, glass blocks are suggested for cleanliness and a cheerful atmosphere. Waste disposal units are designed to be totally recessed in the wall with removable sections for emptying. The plastered ceiling is furred down to the heads of lockers and finished flush with their face. A blower fan forces air into the locker room through ceiling outlets and exhausts the air out through each locker. The air movement into the locker is through slots at the bottom and out through ducts individually connected to the top of each locker. Air is tempered through heating coils in winter. Drying action is definitely noticed on clothes properly hung in the locker. Floors have radiant pipe coils for ideal heating conditions. Floors have separate top finish of either cement or quarry tile. The floor finish is carried 6 inches up on walls and under lockers to act as a base. At Fernandina 5 by 12-inch face color ceramic-glazed wall tiles were used. Terrazzo floors were used throughout and the shower stalls were individual with individual drying compartments. All lighting fixtures were recessed into the plaster ceiling.

PLANT DESIGN

The creed of the modern designer insists that equipment operation and building design are inseparable and indispensible to each other. The recovery boiler building is surely a part of the boiler and is an ideal example of the tremendous design possibilities of modern industrial architecture. The designer is faced with the various mechanical and structural components of a boiler and a precipitator, and he must exhaust all design possibilities, provide for all possible expansion, for maximum flexibility to insure the best economical result.

The location of the precipitator with respect to the cascade or cyclone evaporator must be studied in order to evolve the minimum lengths for ducts, flues, and

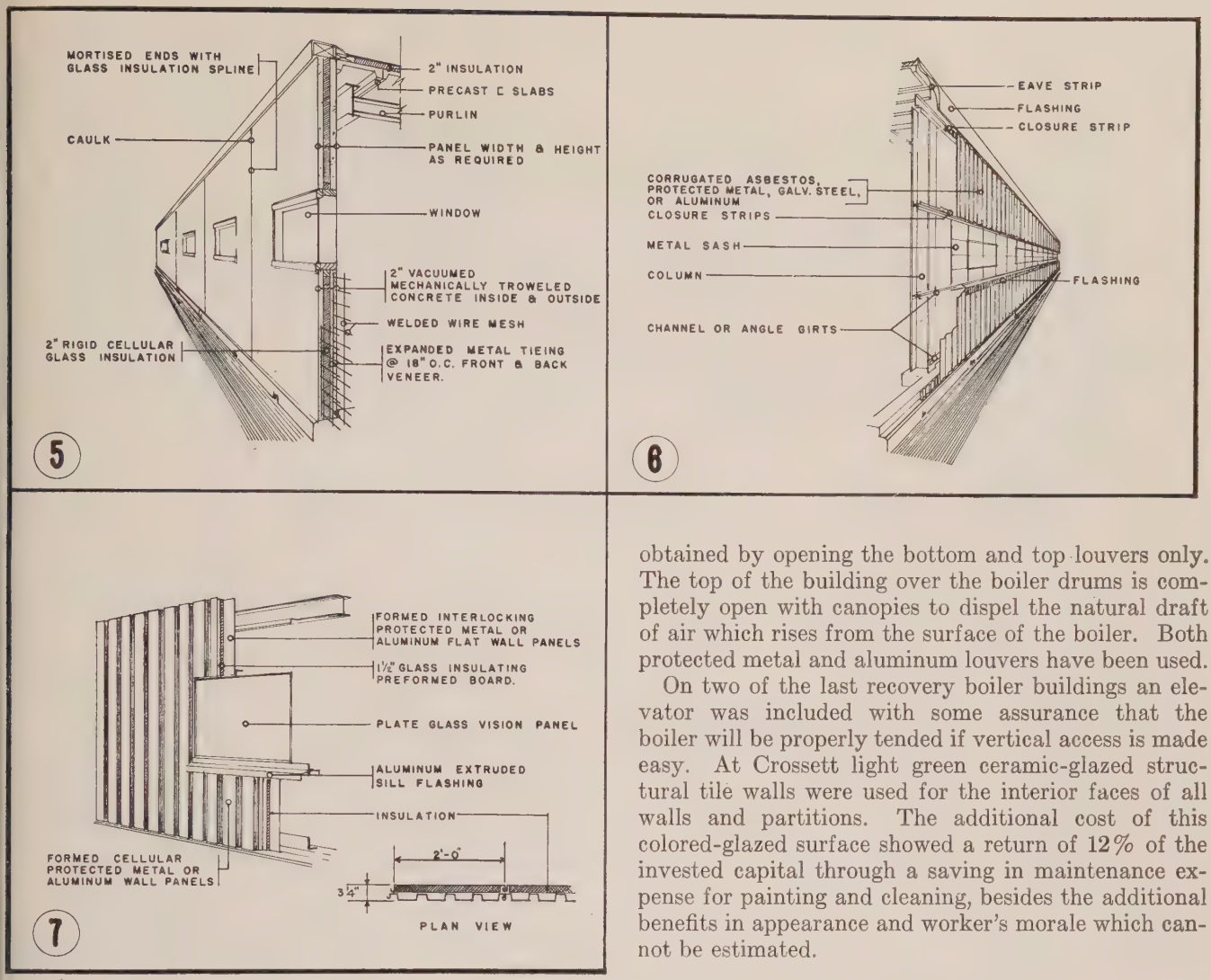

Fig. 4. Wall construction

piping. In several recent recovery boiler buildings, the precipitator was placed directly over the cascade evaporator.

The ventilation problem of this building has always been a troublesome point. Several mills in the South have adopted what can be called an "open-type" building providing wainscoting height wall panels at each floor and over these panels an opening to the spandrel beam of the next floor above. This opening is protected from the elements by a canopy extension. This leaves the operators exposed to weather conditions of all kinds; during good summer weather it is in excellent design since it permits the operators to enjoy all available breezes; during cold spells, and last year it got to zero degrees in many towns in the deep South, it is very uncomfortable and may produce some operational difficulties because of the natural indifference of operators working under such conditions. There is, however, a saving in cost in comparison with an enclosed building of a few cents a cubic foot. In a design which can be called "semiopen," the building is totally enclosed except for one or more vertical bays on each exposure which are covered with operating louvers—during the summer these louvers are kept open and in winter time mostly closed. They are controlled from each floor and some stack action may be obtained by opening the bottom and top louvers only. The top of the building over the boiler drums is completely open with canopies to dispel the natural draft of air which rises from the surface of the boiler. Both protected metal and aluminum louvers have been used.

On two of the last recovery boiler buildings an elevator was included with some assurance that the boiler will be properly tended if vertical access is made easy. At Crossett light green ceramic-glazed structural tile walls were used for the interior faces of all walls and partitions. The additional cost of this colored-glazed surface showed a return of 12% of the invested capital through a saving in maintenance expense for painting and cleaning, besides the additional benefits in appearance and worker's morale which cannot be estimated.

WALL CONSTRUCTION

The author would now like to discuss several typical wall and roof constructions, together with a structural and economic analysis of their advantages and disadvantages. Please understand that this analysis of walls and roofs is subject to considerably different interpretation in various parts of the country and for different uses. This analysis, however, is presented to give a working outline of the various pros and cons of some walls and roofs.

Figure 3 shows four masonry types of wall construction. Earlier the advantages and disadvantages of masonry construction were pointed out. The first wall section indicates a brick wall with structural facing tile used for the inside face. This is a good wall. Tile may be either unglazed, salt-glazed, or colored ceramic depending upon room use. This construction has been used on many mills both in the South and North, and everywhere it has been found to be cheaper and better than solid 8-inch brick. A mechanical bond is used between the two layers by running 2-inch thick soap course in the tile work. The unglazed facing tile is available, depending upon the district, in light buff, light gray, with or without magnesium spots, and in red. Shapes may be had for any of the classifications of tile, but their use will increase the cost considerably.

Section No. 2 indicates an insulated masonry wall, separating the 4-inch brick face and the 4-inch in-

ROOF CONSTRUCTION CONSIDERATIONS

PURLINS NOT CONSIDERED

	MATERIAL	WEIGHT PER SQ. FT.	TOTAL "U" FACTOR	DECK THICKNESS	LIVE LOAD	PURLIN SPACING	FIRE RESISTANCE	SOUND ABSORPTION VALUE	SALVAGE	MAINTENANCE	GENERAL REMARKS
1	PRECAST CONCRETE ROOF SLABS W/2" CELLULAR GLASS INSULATION	18# 20#	.16	2¼" 3½"	30# 30#	6'-4" 7'-0" MAX.	FIRE RESISTIVE	POOR TO FAIR	GOOD	NONE	GOOD LIGHT REFLECTIVE QUALITIES.
2	POURED GYPSUM W/1" RIGID BOARD INSULATION	19#	.18	2½"	30#	8'-6"	FIRE RESISTIVE	GOOD	NONE	NONE	GOOD LIGHT REFLECTIVE QUALITIES. NOT SUITABLE FOR HIGH HUMIDITY CONDITIONS.
3	3" TREATED WOOD DECK W/1" RIGID BOARD INSULATION	15.5#	.14	2⅝"	40#	10'-0"	SLOW BURNING	FAIR	GOOD	MODERATE	REQUIRES SPRINKLERS
4	3" POURED CONCRETE W/2" CELLULAR GLASS INSULATION	41#	.16	3"	60#	8'-0"	1 HR.	POOR TO FAIR	NONE	NONE	GOOD LIGHT REFLECTIVE QUALITIES.
5	CORRUGATED GALVANIZED STEEL	3#	1.50	20 GA.	30#	4'-9"	NON COMBUSTIBLE	POOR	FAIR	PAINTING	SPAN DEPENDS UPON GAGE AND SLOPE.
5	CORRUGATED PROTECTED METAL	3.5#	1.50	22 GA.	30#	4'-9"	NON COMBUSTIBLE	POOR	GOOD	NONE	SPAN DEPENDS UPON GAGE AND SLOPE. AVAILABLE IN BLACK, MAROON AND ALUMINUM FINISH.
5	CORRUGATED ALUMINUM	0.56#	.78 NEW 1.50 DULL	.032"	30#	6'-3"	NON COMBUSTIBLE	POOR	GOOD	NONE	SPAN DEPENDS UPON GAGE AND SLOPE.
5	CORRUGATED ASBESTOS	4½#	.67	⅜"		4'-6"	NON COMBUSTIBLE	POOR TO FAIR	FAIR	LOW	SPAN DEPENDS UPON GAGE AND SLOPE. BRITTLE
6	6" HOLLOW CORE PRECAST CONC. SLABS W/1" RIGID BOARD INSULATION	40#	.22	6"	40#	20'-0" SPAN	4 HR.	POOR TO FAIR	GOOD	NONE	GOOD LIGHT REFLECTIVE QUALITIES. EXCELLENT APPEARANCE REQUIRES NO PURLINS
7	STEEL DECK W/2" RIGID BOARD INSULATION	10#	.14	20 GA.	40#	7'-6"	NON COMBUSTIBLE	POOR	GOOD	PAINTING	
8	INSULATING ROOF TILE	10#	.14	2⅛"	35#	7'-6"	1 HR.	GOOD	FAIR	MODERATE	EXCELLENT LIGHT REFLECTIVE QUALITIES. BOTTOM OF RAIL TO BE PAINTED. WILL ABSORB MOISTURE.

Fig. 5

terior tile by means of a 2-inch thick layer of rigid cellular insulation. The brick is laid up first, then the inside face is coated with an adhesive, the insulation placed against it, then the interior facing is laid in place. Of course, the wall may be had with any variables of masonry, such as, brick, tile, and concrete block. For bonding the two layers the use of noncorrosive wall ties is recommended. This wall has been used extensively in recent textile mill construction and is increasing in popularity. The insulation is available with a vapor-tight seal and in this case would be ideal for high humidity and high or low temperature conditions, both in the North and South.

Section No. 3 indicates a wall which is now being tested and unfortunately there is not much factual information at this time. This wall is being developed in an effort to arrive at a cheap, satisfactory wall for warehouses, machine shops, finishing rooms, etc. It is proposed to lay, say 6 or 8-inch thick cinder blocks laid dry and then finished on the outside and inside with gunite. It has been found that gunite penetrates into the joints of the cinder block and that a satisfactory structural unit for veneer construction is thereby obtained. Such a wall has a disadvantage in that it needs more expansion joints than ordinary masonry.

Section No. 4 indicates an ordinary 7-inch thick reinforced concrete wall. A wall of this nature has no insulation value, is subject to moisture penetration, must be provided with frequent expansion joints regardless of climate. It may be used with either fixed or sliding forms. It should have waterproofing treatment on the exterior.

Figure 4 indicates four panel-type of walls.

Section No. 5 illustrates a precast wall panel which is gaining quite a bit of vogue in Canada. Creighan & Archibald is placing quite a bit of this in the new plant for the Columbia Cellulose Company on Prince Rupert Island. This wall is made up of 2 inches of concrete, 2 inches of cellular glass insulation, and finished with 2 inches of concrete. The two concrete sections are tied together with webbing of expanded mesh. It is individually engineered for each job and of course is subject to a great fluctuation in cost depending upon the number of similar units, height span, etc.

Section No. 6 indicates the ordinary corrugated wall made of either asbestos, galvanized steel, protected metal, or aluminum. This is the cheapest wall known and its limitations are well known.

Section No. 7 indicates a preformed steel faced wall panel. This wall construction was used recently in

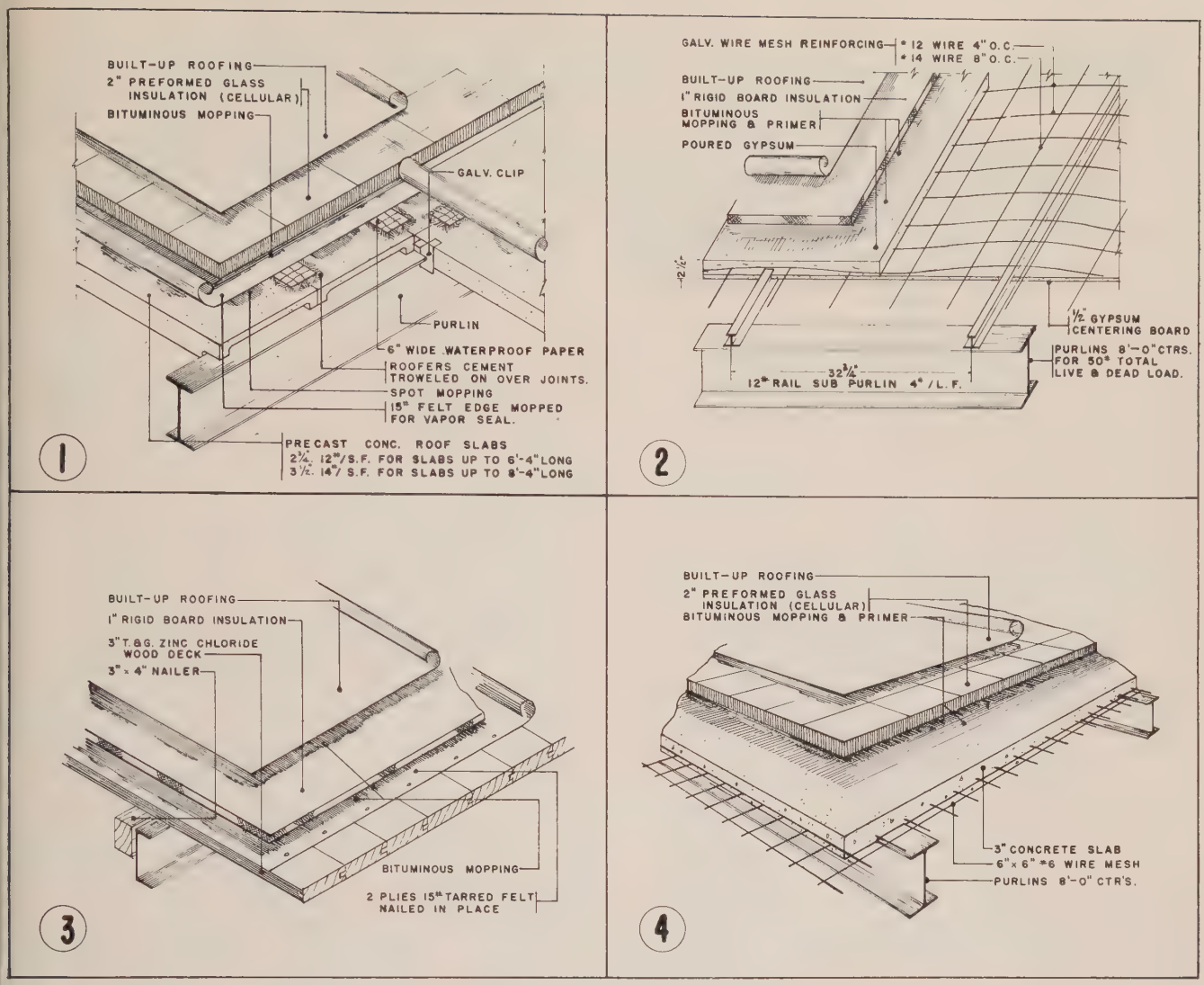

Fig. 6. Roof construction

the new St. Regis mill at Tacoma, and there are reports that it is eminently successful and that they are quite pleased with it. It is made up of steel Q-panel on the exterior, then $1^1/_2$ inches of glass-insulating board, and an interior finish of interlocking flat wall panels. The unit comes preassembled completely engineered for the job and is bolted to steel girts or spandrels at the job site. This type of construction is very different from the traditional masonry. It has an excellent insulation value. The exterior facing is available in formed aluminum to reflect solar radiation for southern application. The interior finish is also available in aluminum or steel with choice of finishes. In the South the exterior panel acts as a vapor barrier in the summer. In the North this interior surface acts as a vapor barrier to ward off condensation. The interior surface may also act as a reflective surface to save artificial light and at the same time retain heat within in winter.

ROOF CONSTRUCTION

Figures 5, 6, and 7 indicate some suggestions for roof construction. High humidity conditions and various types of insulation have been considered. Number 1 is the design which the author's company has used the most frequently—a precast concrete roof slab covered with insulation and built-up roofing. This is an excellent roof construction for practically all paper mill rooms. It is a fire-resistant, maintenance-free construction giving a good light reflectance with an excellent insulation value. This is an ideal roof for paper machine rooms. In New Hampshire, it was used with 3 inches of foamglass insulation. In Florida, it was used with 2 inches of the same insulation. It is not affected by the high humidity. Please note the use of the 6-inch wide strip over the joints to prevent drippage of pitch or asphalt under high temperature conditions.

Section No. 2 indicates a poured gypsum roof that has only limited use in paper mill work. It cannot be used successfully in any high humid atmosphere. It makes good roofing for rooms such as finishing departments and warehouses.

Section No. 3 indicates the old mill favorite—the T & G wood deck fastened to nailers which are fastened to steel purlins. The use of such a roof immediately requires sprinklers and except for expansion programs where roofs adjoin existing roofs of such construction, this roof is losing some of its popularity.

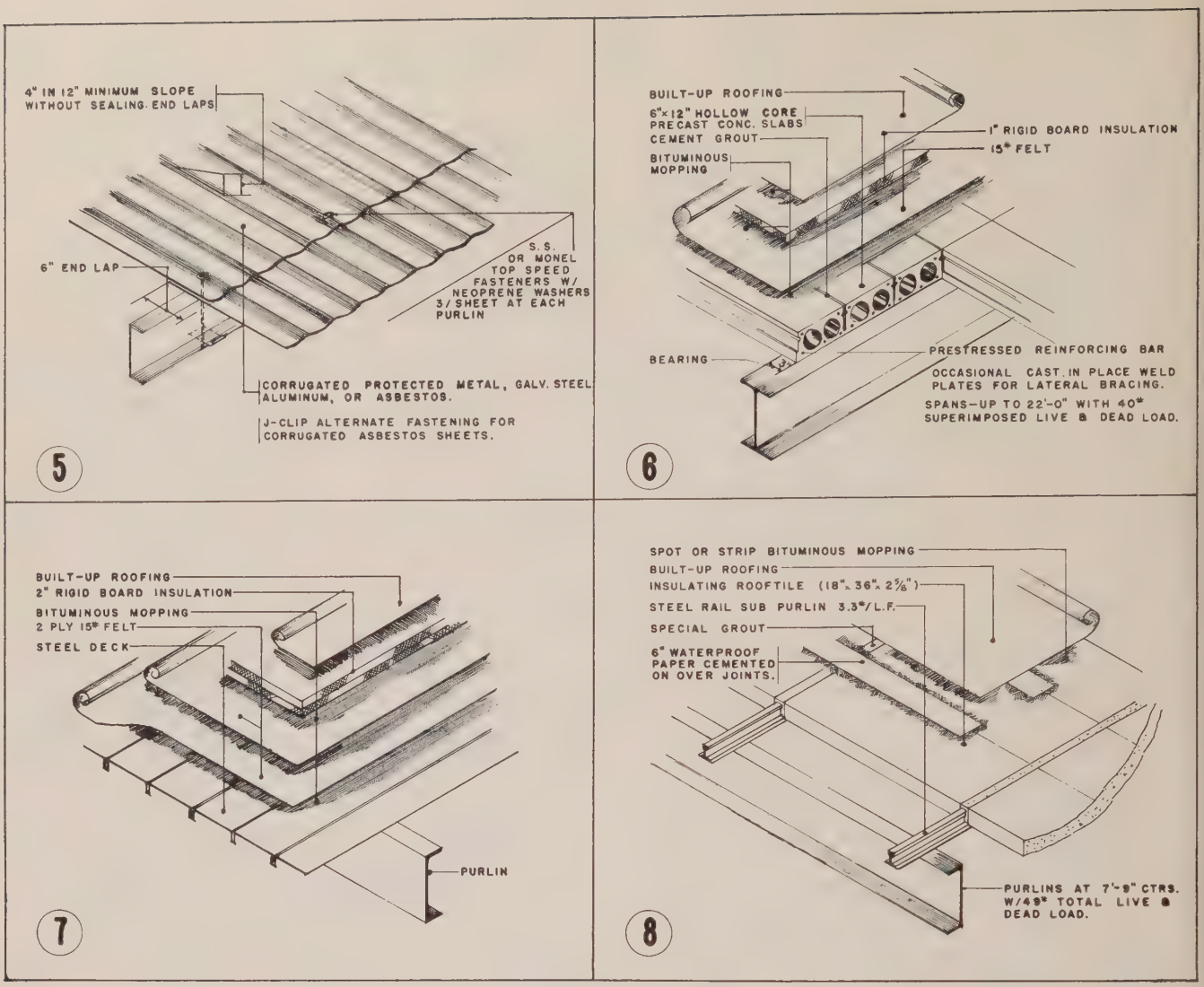
4" IN 12" MINIMUM SLOPE WITHOUT SEALING END LAPS
6" END LAP
S.S. OR MONEL TOP SPEED FASTENERS W/ NEOPRENE WASHERS 3/SHEET AT EACH PURLIN
CORRUGATED PROTECTED METAL, GALV. STEEL ALUMINUM, OR ASBESTOS.
J-CLIP ALTERNATE FASTENING FOR CORRUGATED ASBESTOS SHEETS.
5
BUILT-UP ROOFING
6"×12" HOLLOW CORE PRECAST CONC. SLABS
CEMENT GROUT
BITUMINOUS MOPPING
1" RIGID BOARD INSULATION
15# FELT
BEARING
PRESTRESSED REINFORCING BAR
OCCASIONAL CAST IN PLACE WELD PLATES FOR LATERAL BRACING.
SPANS—UP TO 22'-0" WITH 40# SUPERIMPOSED LIVE & DEAD LOAD.
6
BUILT-UP ROOFING
2" RIGID BOARD INSULATION
BITUMINOUS MOPPING
2 PLY 15# FELT
STEEL DECK
PURLIN
7
SPOT OR STRIP BITUMINOUS MOPPING
BUILT-UP ROOFING
INSULATING ROOFTILE (18"×36"×2⅝")
STEEL RAIL SUB PURLIN 3.3#/L.F.
SPECIAL GROUT
6" WATERPROOF PAPER CEMENTED ON OVER JOINTS.
PURLINS AT 7'-9" CTRS. W/49# TOTAL LIVE & DEAD LOAD.
8

Fig. 7. Roof construction

Section No. 4 indicates a 3-inch poured concrete slab. This is excellent heavy construction.

Section No. 5 indicates the cheapest possible roofing—any of the corrugated materials, such as, galvanized steel, protected metal, aluminum or asbestos. Recently a vogue has been started for the use of insulated corrugated sandwich-type roofs and walls. This may have attractive possibilities.

Number 6 illustrates a patented type of floor which can be used in some parts of the country within proper shipping distance from the 14 points of manufacture. This design will span up to 22 feet long and therefore presents a beautiful appearance from the floor below, eliminating intermediate floor or roof beams. This same unit can be used at floor slabs. It is being used as a warm air radiant panel floor system for good heating. It has all the advantages of concrete construction.

Number 7 indicates the ordinary steel decking material. This presents a painting maintenance and is not recommended for humid atmosphere. It is, however, quite satisfactory in dry atmosphere.

Section No. 8 indicates a new roofing material which is becoming very popular as a result of its excellent qualities and low cost. It is an insulating roof tile at the present made in Bloomfield, New Jersey. It has most of the advantages of precast concrete roof slab, together with some additional advantages, such as, a much better K-value. Its soft surface also rates well acoustically. Its chief disadvantage is that the bottom face of the small steel rails must be kept painted. It too requires stripping of side joints to prevent drippage of asphalt or pitch under high temperature conditions. Moreover, since the author's company has not used it under high humidity, he does not know how it will react.

These notes on the building shell and its environment indicate to a great extent the possibilities that become true when it is said that the better they work, the better they look.

The type of design that has been mentioned will produce four major advantages: the first, an increase in the capacity for production; second, an increase in profit due to savings in all over production costs; third, a beneficial influence on the body and spirit of the worker; and last, dignity and beauty which increase confidence in the community and its industry.

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The Potassium Permanganate Method for Determining the Reducing End-Group Content of Cellulose

*With Comments on a Novel Concept of the Molecular Structure of Cellulose**

ALEXANDER MELLER

On subjecting a surgical cotton wool sample to the action of potassium permanganate solution in the presence of sulphuric acid at 0° C. for increasing periods of time, the oxygen consumption did not reach finality as claimed by the originators of this method for determining the end group content of cellulose. Variation of the amounts of potassium permanganate and sulphuric acid changed the rate of oxygen consumption, but a leveling off in the oxidation rate plots could not be observed. Hydrocelluloses prepared from the surgical cotton cellulose showed an apparent lower reducing power as evidenced by a slower oxygen consumption. Only 0.3% material was solubilized during the acid treatment of the cellulose sample in preparing the hydrocelluloses. This removal in conjunction with the polymolecularity and the supermolecular structure of cellulose in fibers (amorphous and crystalline regions) may explain the lower oxidizability (reactivity toward acid permanganate solution) of the hydrocelluloses. The novel concept of the hemiacetal cross-linked cellulose structure is discussed. It appears that the experimental evidence pertaining to the postulations are either insufficient or contradictory. Many observations of the originators of the novel concept of cellulose constitution may be explained by the polymolecularity of the glucose chains and by the supermolecular structure of cellulose fibers. It is concluded that more experimental evidence is needed to prove convincingly the presence of covalent cross-bonds operating between adjacent glucose chains in cellulose fibers.

In a recent article Pacsu (*1*) surveyed in an analytical manner the proofs which have served as a basis for the well-known formulation of the linear molecular chain constitution of cellulose. He arrived at the conclusion that "it is justifiable from every point of view to regard cellulose as a chain molecule containing at least 99% of β — 1, 4 glucopyranosidic bonds." He advanced a new concept of the molecular composition and structure of cellulose (and starch) which was based on the results of studies published recently (*2*). According to this novel contention of the molecular structure of cellulose, simple sugars in hydrated open chain form hold the long chain molecules together by means of hemiacetal linkages. These simple sugars would thus function as cross units between adjacent polymeric glucose anhydride chains and the hemiacetal linkages would hydrolyze more rapidly than the normal glucosidic bonds.

Experimental evidence furnished for supporting this concept was based on the following observations:

1. Mild acid treatment of cellulose samples caused a large decrease in tensile strength but further action even with stronger acids caused no appreciable change in the chemical and physical properties of the acid treated fibers.
2. Hydrocellulose samples, prepared under not very drastic conditions, showed a lower reducing power (lower end-group content) than the celluloses from which they had been prepared, in spite of the fact that "no weight loss at all on the scales" could be detected as a result of the acid treatment applied in preparing the hydrocelluloses.
3. Cellulose fibers dissolved in phosphoric acid solution did not reveal optical rotation characteristic for glucose.
4. The viscosity of a dispersion of cellulose in phosphoric acid decreased on standing without a parallel decrease in end-group content as determined by the potassium permanganate method.

In addition, in a subsequent paper (*3*) it was suggested that hydrolysis with dilute organic acids at high temperatures is very rapid in the initial stages and comes to a standstill when the D.P. has reached about 250 for cotton and about 60 for viscose yarn. The mild hydrolysis was maintained to affect only the hemiacetal bonds, so that it stops after the "limit hydrocellulose" has been formed (D.P. of about 250 for cotton and about 60 for viscose rayon).

The inferences from these observations were that weak acids do not hydrolyze appreciably the normal glucosidic linkages but the hemiacetal bonds, connecting the "primary chain molecules" laterally together. By leaching out the cross-linking molecules (one for every 548 glucose residues) of high-reducing power from the "secondary molecules," the hydrocelluloses were found to be of lower end-group content. Phosphoric acid was postulated to cause only a cleavage of the hemiacetal cross linkages and rupture of hydrogen bonds and as no hydrolysis to glucose takes place, this would account for the absence of optically active glucose in a solution of cellulose in phosphoric acid. The great solution viscosity of cellulose in phosphoric acid was ascribed to the presence of large "molecule aggregates," "secondary chain molecules," and true cellulose molecules. Finally the results of the latest rate studies on the depolymerization of cellulose by dilute organic acids were considered as the "crucial test for the new theory of cellulose structure" and they were regarded "as a partial confirmation of the new theory," i.e., the hemiacetal cross-linked glucopyranose chains.

* The novel concept referred to was advanced by E. Pacsu of the Frick Chemical Laboratory and the Textile Foundation at Princeton University.

Alexander Meller, Senior Research Chemist, Australian Paper Manufacturers Ltd., Melbourne, Australia.

Undoubtedly this novel interpretation of the molecular structure of cellulose would invalidate many conclusions drawn by other investigators from viscosity and kinetic studies on cellulose fibers. In addition the implications of interpreting the reactivity of fibrous cellulose by the relative proportions of crystalline and amorphous regions would lose foundation. Indeed, the reactivity would be largely governed by the number of cross linkages which would split much faster than the glucosidic bonds.

The evidence offered by Pacsu and collaborators and the postulations advanced may justify critical examination because of their important bearing on the interpretation of the behavior of cellulose fibers. Furthermore, in connection with reactivity studies of fibrous cellulose pursued by the writer (*4*), it appeared that if the permanganate method for determining the end-group content of cellulose is reliable, then it may serve as a simple and convenient method for interpreting the accessibility of the end groups in different cellulose fibers.

OBJECT

The object of the present investigation was (1) to test the reliability of the permanganate method for assessing the end-group content as a possible basis for the interpretation of the accessibility of reducing end groups in cellulose fibers, and (2) to discuss the novel concept of the molecular constitution of cellulose and its bearing on the reactivity of fibrous cellulose.

EXPERIMENTAL

Materials Used

The materials used were surgical cotton wool of commercial grade and hydrocelluloses, which were prepared from the surgical cotton wool by treatment with 1 *N* sulphuric acid solution at 60°C. for 3 hours hot water, soaking in cold water, and washing with hot water. Drying was performed at 105°C. and in a water. Drying was performed at 105°C. and in a standard constant humidity room, respectively (70°F.; 65% relative humidity). These hydrocellulose samples are designated as hydrocellulose C_{105} and C_A.

Methods

1. The end-group content was estimated by the method of Hiller and Pacsu, the only difference being that instead of adding the mixture of fibers and acid solution to the permanganate solution, the latter was added to the former. The volume of *N*/10 potassium permanganate solution and the strength of the sulphuric acid solution were varied as shown in Table II.

Table I. Showing the Characteristics of Cellulose Samples

Sample	*Carboxyl content, milliequivalent/100 g.*	*Viscosity, cp.*	Yield[a]
Surgical cotton wool	2.07(1)[b] 2.03(16)[b]	1050	100
Hydrocellulose C_{105}	1.25(1)[b] 1.33(16)[b]	84	99.7
Hydrocellulose C_A	1.38(1)[b]	250	99.7

[a] As a result of treatment with 1 *N* sulphuric acid the loss in weight was determined and the yield values quoted are based on original surgical cotton wool taken as 100.

[b] The figures in brackets indicate the number of hours of reaction with the sodium bicarbonate solution.

Table II. Showing the Experimental Conditions Applied in the Permanganate Method and the Rate of Oxygen Consumption

A. Surgical Cotton Wool

Reaction time, hr.	*Milliequivalent of oxygen used per 100 grams of fibers* ⊙	×	△	●	⊡
1	6.1	5.1	4.6	4.2	4.6
2	7.1	6.4	6.2	5.7	5.9
3	7.9	7.4	6.7	6.5	6.6
4	8.6	8.0	7.1	6.9	7.0
5	9.2	8.5	7.5	7.4	7.3
6	9.7	8.8	7.8	7.6	7.5
16	13.0	11.3	11.1	9.7	10.3
17	13.3	11.5	11.4	9.9	10.5

Reaction conditions: 1 gram of fibers in 200 ml. reaction mixture

	Reaction Mixture		
	0.1 N $KMnO_4$, ml.	*0.5 N H_2SO_4, ml.*	*Water ml.*
⊙	7	100	93
×	5	100	95
△	3.5	100	96.5
●	2.5	100	97.5
⊡	3.5	50	146.5

B. Hydrocelluloses

Reaction time, hr.	*Milliequivalent of oxygen used per 100 grams of hydrocellulose* *Hydrocellulose C_{105}*	*Hydrocellulose C_A*	
1	3.5	3.4	2.7
2	4.5	...	...
$2^1/_2$	...	4.9	...
3	...	4.5	3.8
$3^1/_2$	5.0	...	...
4	...	4.9	...
$4^1/_2$	5.3	...	...
5	...	...	...
6	6.2	5.9	4.5
16	...	7.4	6.4
$16^1/_4$	7.5	...	...
$16^1/_2$	...	8.2	6.6
$16^3/_4$	8.0	...	...

2. The carboxyl-group content was determined according to a recently published method by Karin Wilson (*5*). In order to see the accessibility of the reagent to the fibers and the possible presence of alkali sensitive linkages in the cellulose samples, the period of reaction was varied. The implications of the former were discussed by Meesook and Purves (*6*) and those of the latter by Davidson and Nevell (*7*).

These are listed in the tables below together with the variables of experimental conditions, and shown by the graphs in the figures.

The results of experiments on the oxidation of surgical cotton with potassium permanganate show that the oxygen consumption increases with time and a leveling off in the oxidation rate plots could not be observed (Fig. 1). The originators of the permanganate method for determining the reducing end-group content of cellulose recommended the addition of an amount of potassium permanganate equivalent to ten times the amount required for the reaction. As the results show, by a large decrease in the excess of potassium permanganate the rate of oxygen consumption decreased. A leveling off, as claimed by Hiller and Pacsu, could not be substantiated with the surgical cotton wool sample applied (Fig. 1). In addition, the rate of oxygen consumption was found to be influenced by the acid concentration of the reaction mixture (Fig. 2).

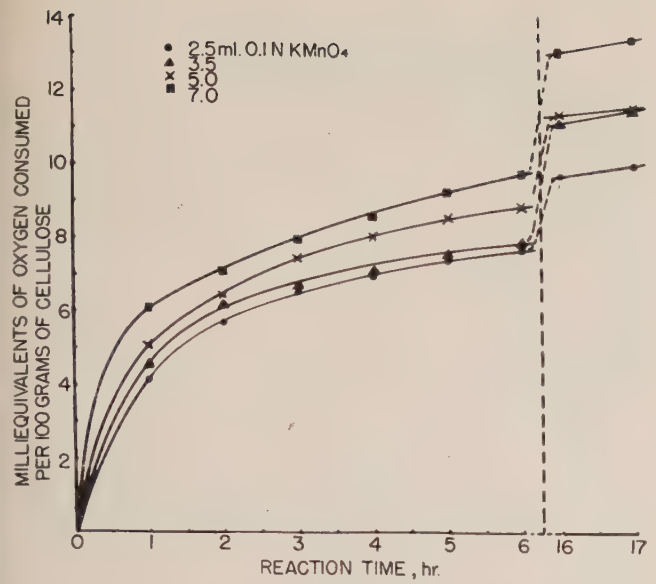

Fig. 1. Rate of permanganate consumption by cellulose fibers at different permanganate concentrations

The hydrocellulose samples showed an apparent lower oxygen consumption or, better, a lower rate of oxygen consumption than the surgical cotton from which they had been prepared (Fig. 4). During the making of the hydrocellulose by means of 1 *N* sulphuric acid, only 0.3% material was solubilized. The carboxyl-group contents of the hydrocelluloses were lower than that of the surgical cotton wool (Table I). The 0.3% material removed during the acid treatment and the lower carboxyl-group content of the hydrocelluloses do not permit us to draw any conclusions with regard to the nature of the materials dissolved during the acid treatment. If shorter chain-components were removed, the residue (hydrocellulose) becomes enriched in longer chains and would show a lower end-group content. Similarly, oxidized chains passing into solution during the acid treatment would contribute to a reduced acid-group content of the hydrocellulose. During the acid treatment, however, degradation of the long chains as well as oxidation by the interaction of atmospheric oxygen may occur, both opposing the effects mentioned above (*8*). The apparent lower reducing power of the hydrocellulose may thus be explained by the removal of short chain components of the fibers. That a degradation during acid treatment took place was borne out by the lower cuprammonium viscosity of the hydrocelluloses when compared with the parent surgical cotton fibers. A possible explanation for the slower reaction with the hydrocellulose would be that during the acid treatment (*9*) or in the subsequent drying a recrystallization may have taken place which may contribute to a decreased reactivity toward acid-permanganate.

The results of permanganate oxidations of the hydrocelluloses used in the present investigation also show that the oxygen consumption increased with reaction time and a leveling off in the oxidation rate plots could not be noticed (Fig. 3). That the drying did not affect the reactivity (oxidizability) of the hydrocelluloses significantly was borne out by the practically equal rates of oxygen consumption of the differently dried samples (Fig. 4).

In the light of the results of the present investigation the permanganate method for determining the reducing end-group content of cellulose and hydrocellulose cannot be regarded as satisfactory in the simple form recommended. One criterion of a satisfactory determination of the end-group content is not fulfilled because the reaction proceeds indefinitely instead of reaching finality, as claimed by the originators of this method.

COMMENTS ON THE NOVEL CONCEPT OF THE MOLECULAR CONSTITUTION OF CELLULOSE

In view of the results obtained and discussed above the lower end-group content of the hydrocelluloses observed by Hiller and Pacsu may be explained by the polymolecularity of cellulose. During acid treatment of cotton fibers, in making the hydrocelluloses, short-chain constituents of high-reducing power may be solubilized rendering the residue richer in long-chain components, hence a lower end-group content. Heuser (*10*) pointed out that this reduced end-group content could be explained without resorting to a new hydrocellulose concept and a new cellulose formula.

Pacsu's new view on the chemical structure of cellulose and particularly of starch was also criticized by Halsall, Hirst, and Jones (*11*). It was suggested that the yield of formic acid, obtained by these investigators on oxidizing starch by potassium periodate, would not be compatible with the formula having hemiacetal cross bonds.

The fast initial depolymerization observed by Pacsu and collaborators may be explained by visualizing that the hydrolyzing reagent penetrates faster in the amorphous regions of the fibers and ruptures the glucosidic bonds at a higher rate than the same type of bonds in the crystalline areas (*4, 12, 13, 14, 15, 16*).

It is also conceivable that during the isolation processes of the fibers (kiering, bleaching, etc.) groupings of the glucose units, particularly in the amorphous domains, may undergo chemical changes. The consequence of the chemically changed groupings in the glucose units may be that both the stability of the glucosidic interunit bonds and the strength of the

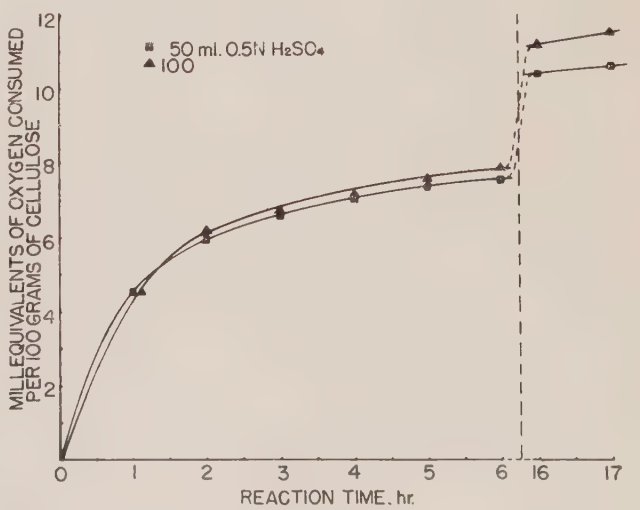

Fig. 2. Influence of acid concentration on the rate of permanganate consumption by cellulose fibers

hydrogen bridges operating between adjacent chains are affected. Slight chemical modifications occurring in the glucose units may bring about changes in the behavior of the glucosidic bonds as well as in the supermolecular structure of the fibers. In other words some irregularities in the cellulose molecules in the longitudinal direction and in the distribution of amorphous and crystalline areas may be responsible for the initial fast depolymerization observed. This view would explain satisfactorily the observations of the rate of depolymerization of a hydrocellulose sample by 5 *N* hydrochloric acid being approximately of the same magnitude as that for the later part of depolymerization of the parent pulp cellulose (*1*). Hydrolytic degradation would proceed fast in the easily hydrolyzable (amorphous) regions and may reach finality within comparatively short time. In the crystalline or difficultly hydrolyzable regions the depolymerization may proceed at a lower rate, approximately equal to that of the hydrocellulose sample which does not contain the greater part of amorphous or easily hydrolyzable fractions because these have been removed during the preceding treatment with acid (*4*). Mehta and Pacsu's argument that the widely held view on the supermolecular structure of fibrous cellulose meets several difficulties in explaining that "the reaction stops after the 1,4-glucosidic bonds in the amorphous region have been hydrolyzed," cannot be accepted. In the first place the reaction does not stop and the depolymerization does not seem to come to a "standstill at a definite stage," because these statements are contradicted by the experimental evidence. With the exception of one experiment the depolymerization did not reach constant values but showed a definite trend to decrease with time of hydrolysis. These decreases can hardly be neglected and hence the experimental results cannot be reconciled with the conclusion, according to which "it thus seems to be definitely established that under mild conditions of hydrolysis, whether by mineral or by organic acids, hydrolysis of cotton cellulose comes to a standstill at a definite stage, when the material has a D.P. of about 250." On the contrary, the slow decrease of depolymerization proceeding in the later stages of hydrolysis can be regarded as an additional support for the postulation that the rate plots, derived from kinetic studies of heterogeneous depolymerization reactions

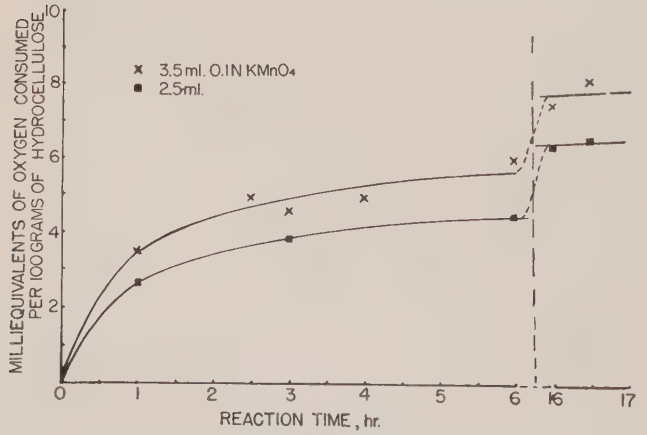

Fig. 3. Rate of permanganate consumption by hydrocellulose at different permanganate concentrations

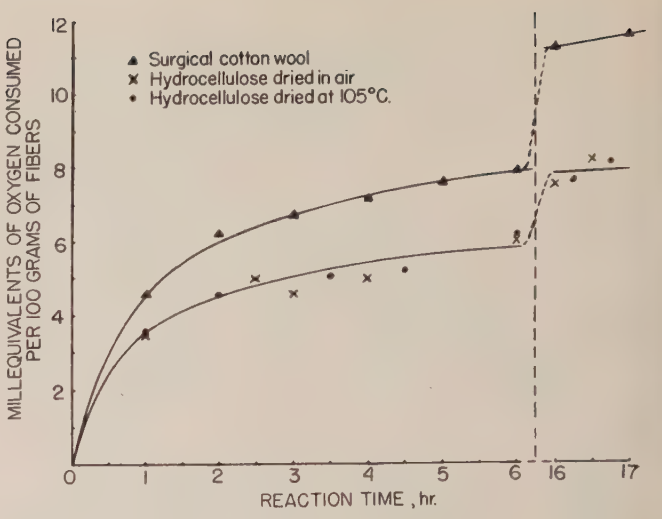
MILLIEQUIVALENTS OF OXYGEN CONSUMED PER 100 GRAMS OF FIBERS
Surgical cotton wool
Hydrocellulose dried in air
Hydrocellulose dried at 105°C.
REACTION TIME, hr.

Fig. 4. Comparison of rate of permanganate consumption by different cellulose fibers

with cellulose fibers, represent a superposition of a fast reaction with the amorphous constituents upon a slow reaction in the crystalline regions.

A further argument put forward by Mehta and Pacsu, that the present view on the supermolecular structure of fibrous cellulose may not explain why the amorphous and crystalline areas assessed by kinetic methods applying aqueous solutions do not agree with the results derived by applying physical methods, has been explained by several investigators (*9, 17, 18*).

Hiller and Pacsu, on investigating the hydrolysate for reducing value (i.e., the reducing power of the sulphuric acid solution obtained by hydrolyzing surgical cotton fibers), concluded that one cross bond for every 548 glucose units should be present in the cellulose molecules. This postulation was supported by an analytical figure obtained by determining the reducing power of one single hydrolysate. The corresponding loss in weight as a result of hydrolysis would be approximately 0.3% (*2*). It was stated, however, that no loss in weight could be detected on the scales as a result of the treatment of the cellulose fibers with 1 *N* sulphuric acid.

The two further criterions for a reliable end-group assay are the selectivity of the reagent (i.e., only the reducing end-groups should be oxidized) and that no additional end-groups should be created by degradation.

As to the former, Hiller and Pacsu published results of carboxyl determinations of the permanganate oxidized celluloses. The method applied, however, can by no means be regarded as selective for the end-carboxyl groups but, at the best, it measures all the carboxyl groups present in the oxidized cellulose fibers.

As to the nondegrading nature of acid permanganate solutions under the experimental conditions, it was mentioned that viscosity measurements had been often used for independent checks. No measured values, however, have been reported in the publications.

Further evidence offered for supporting the new concept of the molecular structure of cellulose were the absence of optically active glucose in an aged phosphoric acid solution and the decrease in end-group content.

As to the former, it may be remarked that the nature of reactions taking place between cellulose and phosphoric acid is not fully understood. It is possible that relatively stable addition or swelling compounds are formed (*19, 20, 21*) which subsequently decompose slowly and then depolymerize. The absence of optically active glucose in a dispersion of cellulose in phosphoric acid may, therefore, be partly explained by the presence of relatively stable complexes.

As to the discrepancy between decrease of viscosity and end-group content, it may be noted that the end-group content was determined by the potassium permanganate method the reliability of which is somewhat questionable. Apart from this, as the authors themselves suggested, in an apparently homogeneous dispersion of cellulose in phosphoric acid fragments of micelles or molecule aggregates may be present which slowly break down into smaller units accompanied by a decrease in solution viscosity. This disaggregation may not necessarily create additional reducing end groups.

In connection with the latest evidence offered by Mehta and Pacsu for supporting the new concept of the hemiacetal cross-linked structure of cellulose and of the "limit hydrocellulose," some comments were made above. It may be added that the basic assumption of the authors can only be accepted with some reservation, i.e., weak acids would *first* attack the cross bonds and *later* the glucosidic linkages. It is difficult to visualize why the acid should not attack both types of bonds simultaneously and the glucosidic linkages be attacked only after all the cross linkages have been broken.

It appears that the experimental data are not sufficient for a kinetic mathematical formulation of the hydrolysis of the cellulose samples. Serious objections may also be raised to the method of computation of the energy of activation for the initial hydrolysis of the assumed hemiacetal cross bonds.

The rate constants for the hydrolysis of the hemiacetal bonds for 87 and 97°C. were advanced to be valid from a D.P. of 2500 down to 550 to 600. On the contrary the main postulation was that the mild hydrolysis with the organic acid solutions stops after the "limit hydrocellulose" with a D.P. of 250 has been formed. If the selective hydrolysis of the assumed hemiacetal cross links terminated and the acid did not affect the glucosidic bonds, then the rate constant should be constant and valid for the range of D.P. from 2500 down to 250. Reference should also be made to the somewhat unusual method of computing the rate constants, because only two D.P. values were determined experimentally within the range of 2500 and 550 to 600 and applied for computing the rate constants. These rate constants were evidently derived from the slope of lines obtained by plotting the logarithm of only two D.P. values against time of hydrolysis. This kinetic evaluation, therefore, does not seem to be safe. In the light of the insufficient data furnished for calculating the rate constants both their magnitude and the computed activation energy for the hydrolysis of the assumed cross linking hemiacetal grouping, need confirmation by further experimental results.

It should be emphasized that, although one support for the new contention of the molecular constitution of cellulose could not be substantiated, several observations may be explained without resorting to the novel concept. Some of the postulations have not been supported by sufficient experimental evidence, and one conclusion appears to be in contradiction to the experimental evidence furnished. The results of the present investigation and the comments made should not be interpreted to mean that cross linkages of primary valence nature may not exist in cellulose fibers. Heuser (*22*) in his critical survey on this subject, arrived at the conclusion that the accumulated indirect evidence makes it probable that some type of covalent cross bond may operate between adjacent chains in cellulose fibers.

Finally, assuming that the rate plots obtained in the present investigation represent a superposition of several rates, corresponding to simultaneous oxidation processes or of oxidations occurring in succession, by resolving the rate plots the end-group content may successfully be derived. Similarly they may serve to characterize the oxidizability of cellulose fibers or the accessibility of reducing groups present in the fibers. A decomposition of the rate plots, however, warrants a thorough understanding of the mechanism of the oxidation reactions occurring with the acid permanganate solution, involving the clarification of the problems of its selective and nondegrading action on cellulose fibers.

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Aging of Styrene-Butadiene Latex Modified Starch-Clay Coatings

E. K. STILBERT, R. D. VISGER, and R. H. LALK

Mineral pigment coated papers were prepared in the laboratory with the type of adhesive as the principal variable and the pigment blend as a secondary variable. Clay and a blend of clay and calcium carbonate were used with starch and starch blended with Dow Latex 512K, a styrene-butadiene copolymer, to study the effect of normal aging on the properties of the coated papers. During a period of 15 months of normal aging the brightness and ink receptivity of the papers changed at the same rate in all cases. Both the wax pick and the wet rub resistance of the coated papers containing the latex increased with aging; the greatest increase being obtained with the highest proportion of the copolymer. The flexibility of the coated papers and the retention of flexibility with aging increased directly in proportion to the increase in the proportion of the latex in the adhesive. These results were found to be comparative to the effect of normal aging on commercially prepared coated papers containing the copolymer.

Dow Latex 512K, a styrene-butadiene copolymer, was first sold to the paper industry in the spring of 1946. Its use was as a binder for clay-coated printing papers. Since the supply and price of casein were undependable at the time, the initial commercial work was concentrated on its use as a partial substitute for casein. Since then it has become a standard binder and is in general use with starch, isolated soy protein, soy flour, and glue in addition to being used with casein. In addition to clay-coated papers, it is being used in the manufacture of clay-coated paperboard, wallpaper, fancy-coated papers, and decorative wallboard.

Trial of a latex as a paper coating adhesive was originally made with natural rubber latex. Two patents issued in the early 1930's related to the use of natural rubber latex to modify both casein and shellac (*1*). The process was completely described by Birchard (*2*). Many claims were made for improvements in the properties of the coated papers, but the process never became of commercial importance, probably because of the poor aging qualities of the coated papers.

During the same period developments were being carried forward by several companies in the United States which resulted in the commercial manufacture of synthetic resin dispersions. These dispersions physically resembled natural latex and immediately became known as "synthetic latices." Their development as adhesives for coated papers has been related briefly by Stilbert (*3*).

Since the early days of the commercial use of the styrene-butadiene copolymer, coated paper manufacturers have been concerned about the aging characteristics of coated papers containing it. The fact that there have been no reports of failure in regular commercial printing operations should be evidence enough that the adhesive is satisfactory. However, it is well known that styrene-butadiene copolymers change with age when deposited as a film. Even though the latex is a dispersion of a copolymer developed specifically for use in the unvulcanized state and is very resistant to degradation through oxidation (compared with unvulcanized natural rubber), some hardening does occur on aging. Manufacturers of coated paper are aware that coated papers containing the latex change somewhat with normal aging; therefore, it is desirable to trace the course of these changes.

In the field of off-machine coating, manufacturers are interested in the properties of both protein and starch coated modified papers because the latex is regularly used with both types. Since the quality of coated papers made with either combination is so high, the choice is generally based on the degree of wet-rub resistance required rather than other properties of the coated paper. In the field of machine coating, however, starch is the principal adhesive. Manufacturers are interested in other adhesives and experiment with them continually, but they are most interested in methods of modifying the regular starch adhesive.

For these reasons a laboratory investigation was undertaken using a typical oxidized starch with the copolymer as the adhesive for clay and clay-calcium carbonate coated papers. The properties of the coated papers were measured regularly over a period of 15 months. This report is primarily a summary of the results obtained in this study.

RAW MATERIALS AND THEIR PREPARATION

Dow Latex 512K, a styrene-butadiene copolymer resin dispersion in water, was used throughout the work. This latex contains 45% solids and has a viscosity only slightly above that of water. It is an anionic latex with a pH of 9 to 10.5. The film deposited from the latex is soft, tacky, and elastic. Coatings containing it are slightly thermoplastic, a fact which must be considered in the evaluation of coated papers containing this adhesive.

The polymer was further stabilized in the presence of starch by the addition of 3% casein solids (added as a 15% solution made with a blend of borax and sodium carbonate), based on the latex solids. The latex was diluted to 40% solids before the addition of the casein solution.

The starch used was an oxidized starch, Superfilm

E. K. Stilbert, Member TAPPI; R. D. Visger and R. H. Lalk, Coatings Technical Service, Dow Chemical Co., Midland, Mich.

No. 6, from Stein-Hall Mfg. Co., Inc. A solution of this starch was prepared by mixing 20 parts of dry starch with 40 parts of cold water to make a thin slurry. An additional 40 parts of water was added hot, the whole heated to 80°C. in a steam-jacketed kettle and held for 30 minutes with occasional stirring.

The clay used was a standard grade of domestic coating clay, KCS, from Georgia-Kaolin Co. This grade is the same as SMC in particle size distribution but is pulverized. A water slurry (or "slip") was made by mixing 70 parts of clay with 30 parts of water containing 0.5% tetra sodium pyrophosphate based on the clay. The clay was considered as moisture-free since tests showed less than 1.0% moisture. To get a uniform slip it was mixed for one hour on a Rose "Change Can" mixer.

The calcium carbonate used was a precipitated coating grade from Wyandotte Chemical Co. No attempt was made to work the pigment to lower its adhesive demand. It was used as a 50% slurry in water containing 0.5% tetra sodium pyrophosphate based on the pigment. The pyrophosphate was used to sequester the free calcium ions in the slurry and prevent coagulation of the latex when it was blended into the coating "color." (More recent work has shown that the pyrophosphate used to disperse the clay is sufficient to protect the latex if the calcium carbonate is added somewhat in advance of the latex).

The raw stock used was a regular coating raw stock from Oxford Paper Co. The following are some of the significant properties of this paper:

Basis weight (25 × 38—500) lb.	55
G. E. Brightness	72
Opacity, %	91
Dennison wax pick, No.	9
Cobb size, g./sq. m.	20
MIT fold M. D. (double folds)	7±
MIT fold C. D. (double folds)	7±

PREPARATION OF COATING COLORS

The required amount of starch solution was weighed into the clay or half clay-half calcium carbonate slurry and mixed. The required amount of latex was then added to give a total adhesive content of 18 parts per 100 parts dry pigment. Finally 0.5% 90/10 sulphonated castor oil/pine oil was added (based on total solids) and the resulting coating "color" stirred slowly on an open-wing agitator for 30 minutes. Before being used to coat paper the "color" was brushed through a 140-mesh screen. In each case the screenings were negligible.

The following adhesive blends were used at 18 parts total binder to 100 parts pigment using all clay and half clay-half calcium carbonate.

A. 18 parts starch
B. 4.5 parts latex—13.5 parts starch (25/75)
C. 6.3 parts latex—11.7 parts starch (35/65)
D. 8.1 parts latex—9.9 parts starch (45/55)
E. 9.9 parts latex—8.1 parts starch (55/45)
F. 11.7 parts latex—6.3 parts starch (65/35)

PREPARATION OF COATED PAPERS

In each case the coating color was applied by means of a Martinson doctor-blade coater to a 9.5 by 12 inch sheet of raw stock to give a dry coating of 16 ± 1 pounds per book ream (25 × 38—500). The coated papers were air dried, given two passes through a laboratory supercalender under low pressure, and finally placed in the testing room at 75°F. and 50% relative humidity. All testing and aging was carried out under these conditions.

In general standard tests were carried out on the coated papers. The two notable exceptions were the tests for flexibility and for wet-rub resistance. No existing tests were considered delicate enough to differentiate small changes in these properties of the coatings, changes significant enough to be of interest to the printer even though of a low order.

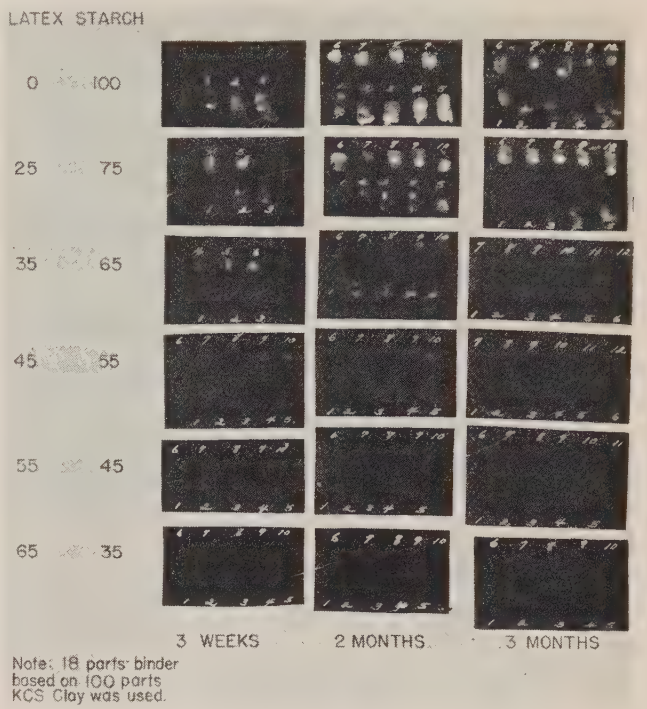

Fig. 1. The effect of latex and normal aging on the wet rub resistance of starch-clay coated paper

Flexibility was determined by folding a corner of the paper with the coating on the inside of the fold at test room conditions. In making the fold the paper was placed on a solid surface with the maximum pressure of the fleshy tip of the index finger pressing along the folded edge. The paper was opened and a finger was rubbed lightly along the open fold on the coated side. If no coating was removed, the paper was rated good. If only a few grains of coating were removed, the paper was rated fair. If more than a few grains were removed, the paper was rated poor. No attempt was made to differentiate between coatings that cracked or did not crack as long as no coating was removed. The test was repeated. If the rating checked it was recorded. If not several more folds were made to establish an average result.

The wet-rub test was based on a test reported by Hewett, Carter, and Church (*4*). Changes were made in an attempt to develop a test that would show the level of water resistance required for offset printing. The fact that regular starch-coated papers are satisfactory for short runs on the offset printing press even

though they have no wet-rub resistance indicates that very little is required to make a satisfactory paper for long runs. The requirements naturally vary with the press and the printing ink. In one instance several million pounds of starch-latex coated paper were printed in long runs in the offset printing of label stock. No difficulty was encountered though the wet rub of the paper could not have been greater than 5 by this method when the paper was printed.

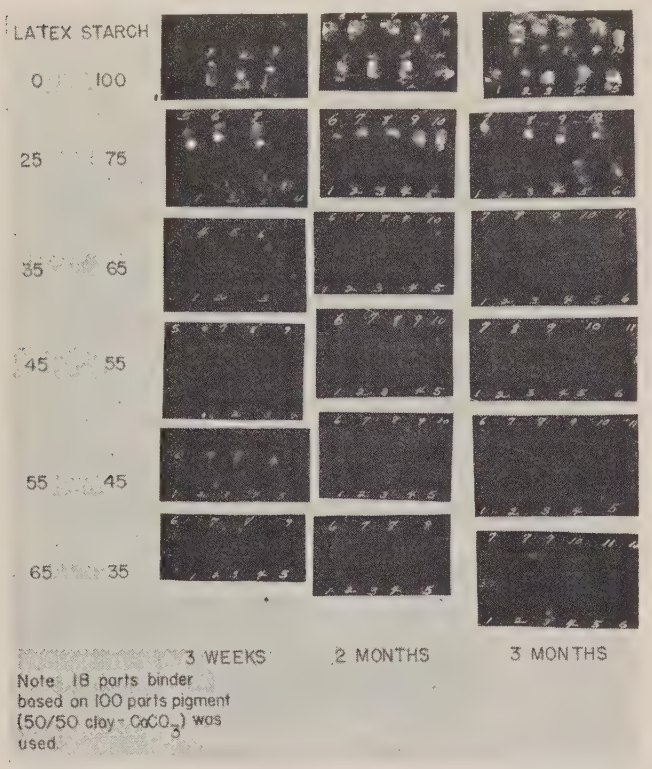

Fig. 2. The effect of latex and normal aging on the wet-rub resistance of starch-clay coated paper

Even though the significance of the test with respect to offset printing may be questioned, there is no doubt that the test is useful in studying the change in resistance of the coating to water with aging when the initial resistance is low.

The test was made by placing a sheet of coated paper over a piece of black, water-resistant, friction-finished weighing paper. The black paper was held in place. Two or three drops of water were placed about $^1/_2$ inch from the edge of the paper on the coated side. Without delay light rubbing was started from the coated surface to the black paper with a minimum pressure of the index finger on the coating. With each rub the paper was moved slightly to establish a new spot for the water. This was done as quickly as possible to get a number of spots as required. When the spots dried they were clear until a point was reached where some coating was removed and the dried spot showed white. The number of rubs necessary to obtain a white spot in this way was taken as the wet-rub resistance.

When the wet-rub resistance was high and only the number (or end point) was desired, it was convenient to use a piece of black plastic sheeting. By rubbing on the same spot for a given number of times, starting over on another spot for a larger number of rubs, etc., the wet-rub resistance of a paper was established even when the resistance was high. Such methods were used to obtain the charts and graphs referring to wet-rub resistance in this paper.

K and N ink receptivity was measured by placing an excess of K and N Testing Ink on the surface of the paper and removing the excess with a spatula and cloth after two minutes. The numerical value was obtained by measuring the per cent reflectance at 580 mmu with a G. E. Spectrophotometer. The method has been described by Kirkpatrick (*5*), and Casey and Libby (*6*).

Brightness was measured with a G. E. Spectrophotometer according to TAPPI Standard T452 m-48.

Wax pick was measured with Dennison Paper Testing Waxes No. 120A according to TAPPI Standard T459 m-48.

Gloss was measured with a Bausch and Lomb Glossmeter according to TAPPI Standard T424 m-45.

EXPERIMENTAL RESULTS

Wet-Rub Resistance

The results of these tests are recorded in Figs. 1, 2, 3, 4, and 5. Figures 1, 2, and 3 are actual photographs

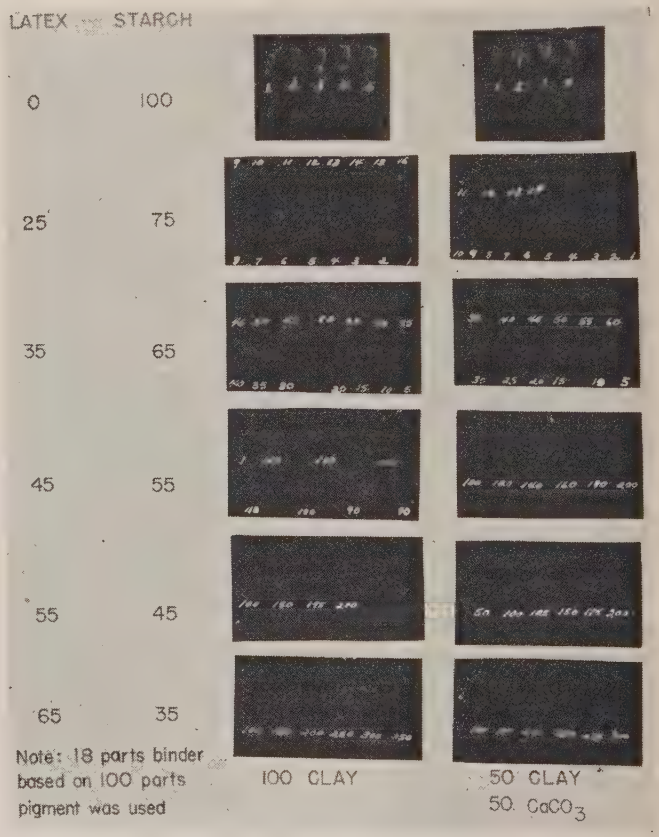

Fig. 3. The effect of latex and 15 months' normal aging on the wet-rub resistance of starch-clay coated papers

of the black papers with the white pigment spots. Figures 1 and 2 show the effect of age and latex content with all clay and half clay-half calcium car-

bonate pigment. They demonstrate that wet-rub resistance increased with age in both series and that wet-rub resistance improved fastest with a high proportion of latex. They also show that wet-rub resistance was developed more slowly when calcium carbonate was used as part of the pigment. Figure 3 shows the results after 15 months of aging. The wet-rub resistance increased tremendously in that period of time under the conditions of test.

The curves of wet-rub resistance vs. age are shown in Figs. 4 and 5.

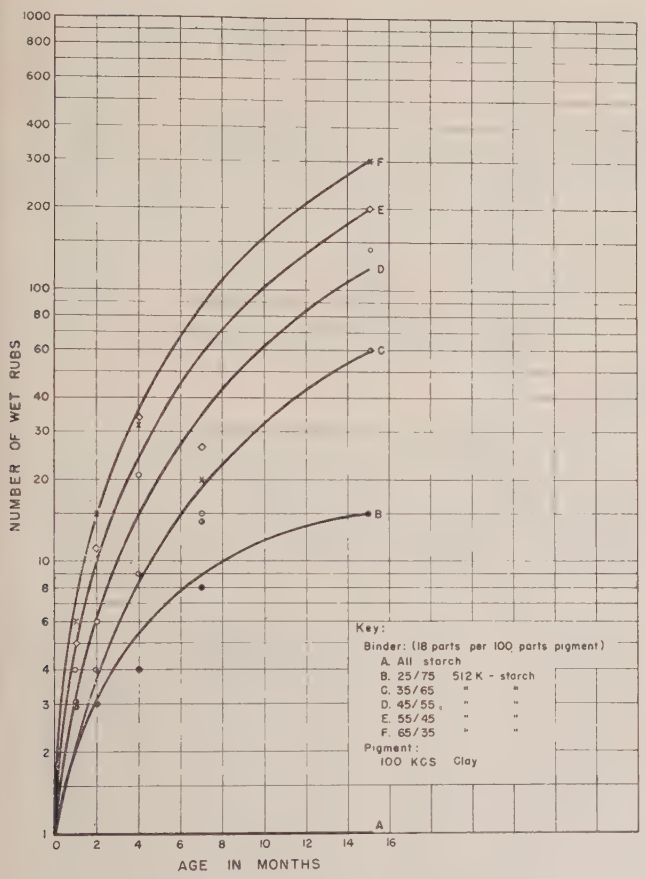

Fig. 4. The effect of latex and normal aging on the wet-rub resistance of starch-clay coated paper

Because only a few sheets of paper were under test for each binder ratio used, the development of wet-rub resistance as noted here must be considered as an accelerated test. In the normal storage of coated paper in a roll or skid the coating would have access to a much lower volume of air per unit weight. This would retard the development of wet-rub resistance. Other laboratory tests and commercial results have confirmed this.

Flexibility

The effect of age and ratio of latex to starch on the flexibility of the coated paper is shown in Table I. The correlation of the results was not too good since the test is not a very exact one. Still the trend of results was definite. Apparently calcium carbonate had a more degrading effect on the flexibility than clay since the all clay coatings retained a measurable amount of flexibility after 15 months even in the lowest concentration of latex. This condition was not noted in papers containing calcium carbonate until a latex concentration of 45% or more of the total adhesive was reached. It is significant that this much loss in flexibility has never been reported to the authors in controlled tests of commercial papers by consumers.

Actually, this too, was an accelerated test since it involved sheets of paper hung in the open with free access of air to the surface of each side. Three years of commercial experience have demonstrated that embrittlement of the coated paper is not a problem when the copolymer is used with starch or protein.

Brightness

Brightness of the supercalendered coated papers was measured only a few times during the entire aging period since it was felt that only slight changes would take place. The results are recorded in Fig. 6. Note that the measurements were close enough that several of the curves were combined to make the picture clearer. The most significant result of these tests was that with normal aging the use of the latex did not effect the brightness of the coated paper any more than starch. The position of the curves is a little confusing.

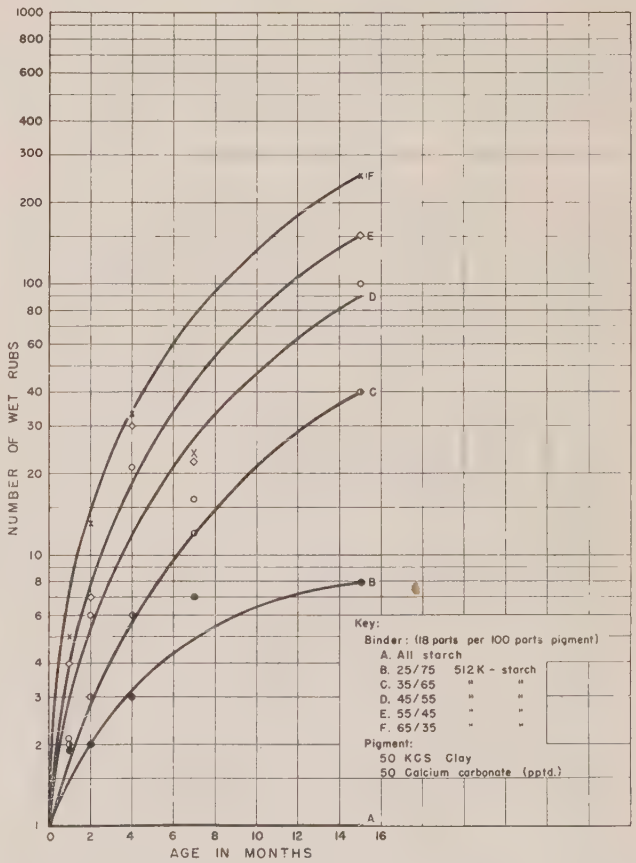

Fig. 5. The effect of latex and normal aging on the wet-rub resistance of starch-clay coated paper

It will be noted that when a mixture of calcium carbonate and clay was used as the pigment, an adhesive consisting of a blend of latex and starch gave better brightness then did starch alone. In contrast, when

clay was used alone as the pigment phase, the highest brightness was obtained with an adhesive consisting entirely of starch. Since these results were duplicated in a large series of tests, it is difficult to conclude that all the curves are within the limit of experimental error.

K and N Ink Receptivity

The results of these tests are shown in Fig. 7. A family of curves very similar to the brightness curves was obtained except that all the curves were in the same order. As would be expected the ink receptivity was greatest when calcium carbonate was used in the pigment formula. Previous experience has shown that ink receptivity at the very same binder content is lower when the latex is used. This result can be varied by altering the supercalendering step. The change in ink receptivity with age was approximately the same for blends of latex and starch as for the starch alone.

Dennison Wax Pick

A discussion concerning wax pick as related to the printing ink resistance of coated papers containing thermoplastic adhesives can be a very controversial one. However, lacking the equipment and the technique for making proof press tests, many mills are forced to use the wax pick test. The results of the wax pick tests are shown in Figs. 8 and 9. They show that wax pick was generally higher with all clay than the half clay-half calcium carbonate pigment. This was to be expected since a precipitated carbonate was used without proper treatment to reduce adhesive demand. It is interesting to note that aging resulted in an improvement in wax pick that was quite significant. This was to be expected with coated papers containing the latex, but the results in Fig. 9 with all starch were unexpected. In Fig. 8 the increases with age were also significant but especially so with the higher proportions of latex.

Table I. The Effect of the Ratio of Latex to Starch and Aging on the Flexibility of Clay Coated Papers

Starch, parts	*Latex, parts*	*Pigment*	*Pigment, parts*	*Latex-starch rat. 10*	*Flexibility with aging*			
					1 wk.	*1 mo.*	*7 mo.*	*15 mo.*
18.0	0.0	Clay	100	0/100	Poor	Poor	Poor	Poor
13.5	4.5	Clay	100	25/75	Good	Fair	Fair	Fair
11.7	6.3	Clay	100	35/65	Good	Good	Good	Fair
9.9	8.1	Clay	100	45/55	Good	Good	Fair	Fair
8.1	9.9	Clay	100	55/45	Good	Good	Fair	Fair
6.3	11.7	Clay	100	65/35	Good	Good	Good	Fair
18.0	0.0	Clay-calcium carbonate	50–50	0/100	Poor	Poor	Poor	Poor
13.5	4.5	Clay-calcium carbonate	50–50	25/75	Good	Good	Poor	Poor
11.7	6.3	Clay-calcium carbonate	50–50	35/65	Good	Good	Good	Poor
9.9	8.1	Clay-calcium carbonate	50–50	45/55	Good	Good	Good	Fair
8.1	9.9	Clay-calcium carbonate	50–50	55/45	Good	Good	Good	Fair
6.3	11.7	Clay-calcium carbonate	50–50	65/35	Good	Good	Good	Fair

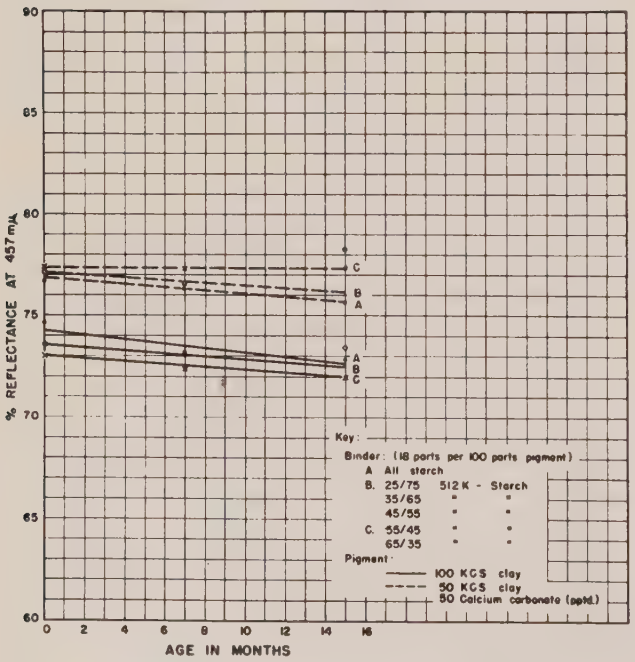

Fig. 6. The effect of latex and normal aging on brightness of starch-clay coated paper

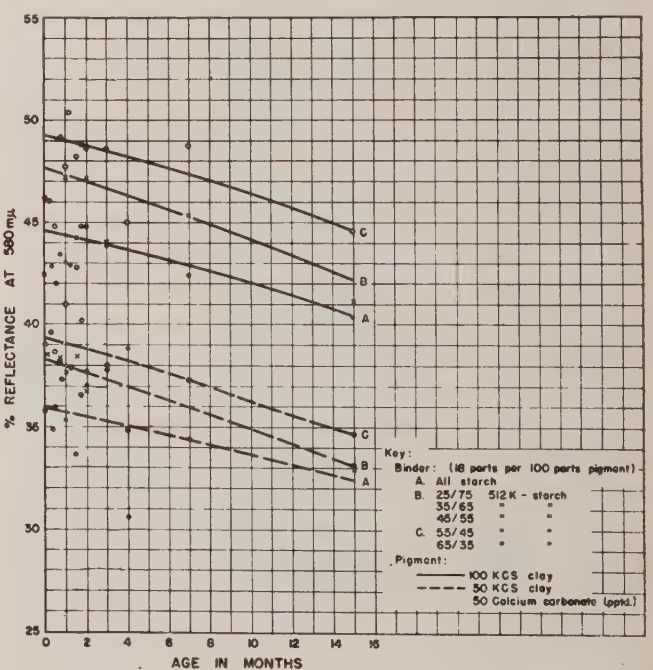

Fig. 7. The effect of latex and normal aging on ink receptivity of starch-clay coated paper

Since the wax-pick test is not as significant when applied to paper coatings containing latex, it is a fair question to ask whether an increase in wax pick with aging can be significant. Another type of test has shown that it is. Coated papers utilizing latex blended with casein also showed an increase in wax pick with normal aging of the coated paper. To check this against actual printing press results another research

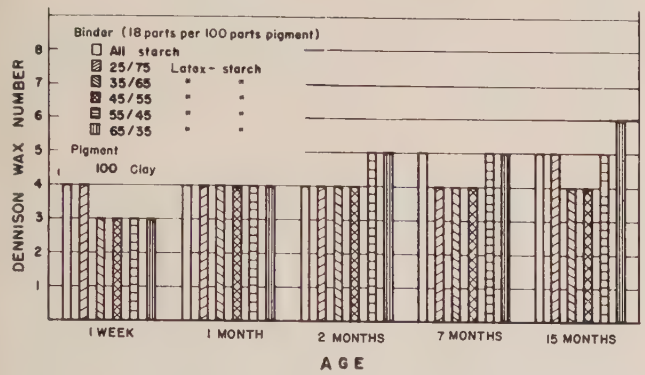

Fig. 8. The effect of latex and normal aging on the wax pick of starch-clay coated paper

laboratory made a comparative series of proof press tests with slack-sized papers fresh and aged for 30 days. The papers were aged in a package, aged in diffused light, and aged in direct sunlight. Proof press tests were made on the fresh and aged papers with an all casein adhesive and a direct replacement of $^3/_4$ of the casein with latex.

The printed papers were mounted and photographed. A printing plate was made from the photograph to give prints as negatives (that is, the white coating picks on the black ink showed up as black spots on a white background). The results are shown in Fig. 10. Note that the paper containing latex picked slightly more than the casein when it was fresh, but was superior to the casein after 30 days of normal aging. This was not true when the paper was aged in direct sunlight.

When the coated paper containing latex was aged by placing in direct sunlight in a window for 30 days, an over-all diminution in binding power of the adhesive occurred as compared with that of the fresh adhesive. While this reduction in adhesive power might result in a coated paper having indifferent printing qualities, it is obviously of little significance because no paper is ever exposed to sunlight for 30 days before printing. The reduction in binding power was apparent only as a result of picking on the proof press as illustrated in Fig. 10.

COMPARISON WITH COMMERCIAL PAPERS

At the time the laboratory work was undertaken samples of a few commercial papers containing the latex were also placed under test. Naturally the exact age of the papers was not the same. However they were all made within a period of two months by the same manufacturer using the same equipment and raw materials. The results of the tests, which were run in parallel with the laboratory coated papers, are recorded in Table II. Although the results were not exactly in line the trends were the same. Since the commercial papers were made with entirely different pigments and adhesives except for the latex, some differences were to be expected in comparison to the

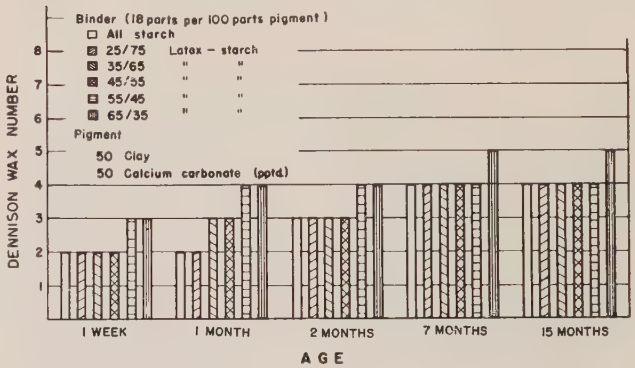

Fig. 9. The effect of latex and normal aging on the wax pick of starch-clay coated paper

laboratory coated papers. The effect of aging on the properties must be considered as accelerated if they are considered as stored unprinted papers. The aging conditions more closely approximate normal aging of printed papers.

Gloss

One of the important characteristics of coated papers is gloss. In this series of tests gloss was neglected because of the problem of interpreting laboratory results on this property. Actually it is well known that higher gloss is the most obvious improvement that can be obtained when latex is used as part of the adhesive. This is due to the plasticity of coatings which allows the coating to actually flow under the action of the supercalender.

Recently a series of commercial runs of coating on

Table II. The Effect of Latex and Aging on the Properties of Commercial Clay-Coated Papers

Adhesive, parts			Pigment, parts			Properties of Coated papers: Wet rubs			Wax pick			K and N ink receptivity			Flexibility		
Latex	Casein	Starch	Clay	$CaCO_3$	TiO_2	1 mo.	6 mo.	12 mo.	1 mo.	6 mo.	12 mo.	1 mo.	6 mo.	12 mo.	1 mo.	6 mo.	12 mo.
4.4	..	20.1	100	..	..	1	6	50	8	8	9	45	41	41	F[a]	P[a]	F
5.9	11.6	..	100	..	..	..	20	200	7	9	10	41	36	37	G[a]	G	F
4.6	11.6	..	81	15	4	18	15	150	9	9	9	53	43	43	F	F	F
3.5	12.0	..	90	10	..	100	200	250	7	9	9	52	45	44	G	F	F

[a] F = fair; P = poor; G = good.

the paper machine presented an opportunity to compare the effect of latex on gloss under controlled commercial operation. The company involved produces a very high-grade machine-coated paper. Special effort is made to produce the best possible surface so that the series presented an excellent opportunity to compare the properties of the papers. . The results of the tests are recorded in Table III. The initial wet-rub tests indicate that the straight starch-clay coating must have had some hardening resin added to give wet-rub resistance. Otherwise the results were in accord with general commercial experience. Note that it was necessary to sacrifice brightness and ink receptivity to get very high gloss. For gloss ink or overprint varnish work, a reduction in ink receptivity is desirable and makes possible a superior printing job. In these tests as in others the wax pick cannot be directly compared. The fact that the use of the latex caused a lowering in wax pick did not mean the resistance to ink picking was less. Several mills have stated that no complaints have been reported back to them on picking of papers containing latex. This is proof that the ink-pick resistance is greater than normal even though the wax pick is generally lower.

Table III. Comparaison of Properties of Machine Coated Papers

Adhesive, parts		*Pigment, parts*		*Properties of coated papers*					
Latex	*Starch*	*Clay*	*TiO_2*	*Gloss, %*	*Flexibility*	*Wax pick*	*Wet rubs*	*G. E. brightness*	*K & N ink receptivity*
0	20	100	..	48	Poor	12	7	72.1	41
0	20	88	12	55	Poor	10	1	77.0	40
5	15	100	..	59	Good	8	2	72.7	45
5	15	88	12	64	Fair	6	1	77.0	44
10	10	88	12	70	Good	10	4	74.8	56

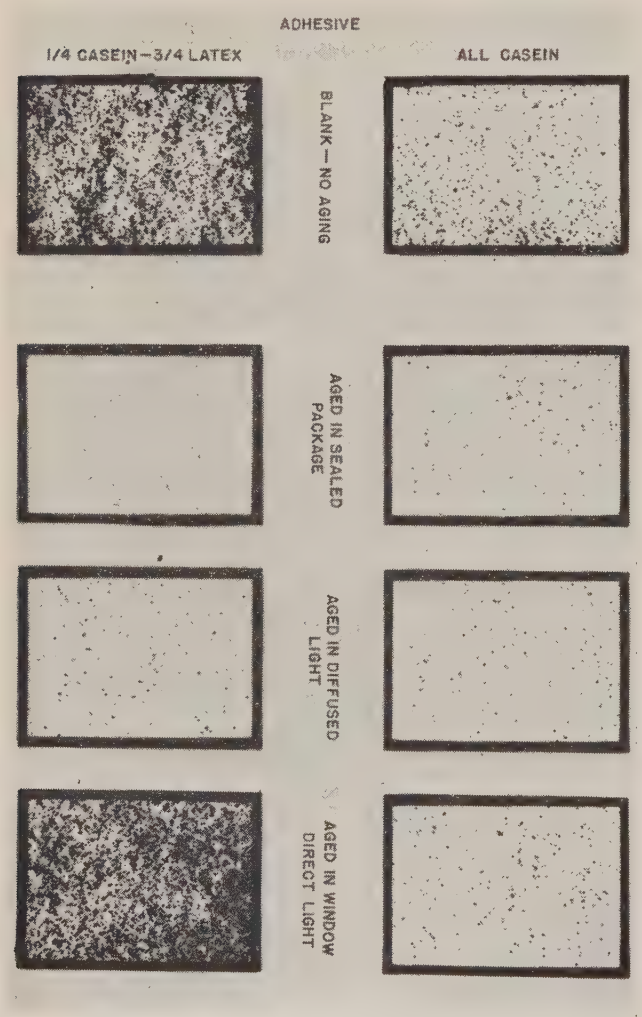

Fig. 10. The effect of normal and accelerated aging on the ink pick resistance of slack-sized papers

CONCLUSIONS

The main object in undertaking this work was to determine the effect of normal aging on the properties of coated papers containing latex. Certainly the results show that age did not adversely affect the properties to a significant degree. Properties such as wet-rub resistance and ink-pick resistance were definitely improved by aging. Some loss of flexibility took place after a year of aging but it was slight even though the tests were somewhat accelerated.

Although the exact results might not be duplicated in commercial practice the same trend in properties should be obtained. Evidence that this is so is backed by a series of parallel tests run on commercial papers which showed the same trend in properties with aging as laboratory coated papers.

There is definite evidence that the use of the latex as a binder presents no unusual problems in the coating of paper. Except for its flexibility and thermoplasticity, it is very similar to the adhesives that have been used in the past. It is a new aid in the improvement of coated papers. As such it is already contributing markedly to the general improvement in the quality of coated papers with a minimum of difficulty and problems to the manufacturer.

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Theory of Saturation of Paper with Resin

RALPH T. NAZZARO

There are many problems involved in the saturation of paper with synthetic co-polymers which in addition to wetting and spreading involve intermolecular electronic forces between solute and solvent, and between the residing polar groups of cellulose and the solute-solvent. These and other factors are discussed briefly in regard to the treatment of paper with a resin or rubber latex.

THERE is no theory of saturation per se. Whatever is said must be regarded as a body of factual information based upon experience for which is found sound technical reasons to explain a given set of phenomena.

The saturation of paper comprises a multiplicity of physico-chemical systems, but for sake of simplicity let us apologize to the physical chemist and look upon the treated paper as composed of two principle systems: namely, paper and the saturant.

Before discussing the nature and properties of each system, we should differentiate between saturation as it relates to tub-sizing and saturation as performed by a paper converter. The manufacturing principles are not as unlike as are the intents and uses of the finished products. In the first method, the tub-size, the final product is still regarded as paper, and, in fact, certain physical properties overlooked in the manufacture of the sheet can be corrected or allowed for in this manner, or certain improvements can be made for the sake of smoothness, writeability, gloss, water and grease repellency, etc. The product, however, is fundamentally paper.

The type of paper conversion usually associated with saturation in the author's experience refers to a procedure whereby a suitable sheet of paper is treated with a rubber, a rubberlike material, or a resin in such proportions that the resulting sheet loses most of the original paper properties and begins to assume the physical characteristics of the dry saturant. The sheet is neither paper nor resin, and its behavior oscillates between paper and resin or rubber.

There is no one particular type of paper which is used in saturation. Apparently, the economics involved generally dictate the nature of the paper stock. In the production of flexible impregnated sheets, the paper bases are made from sulphite prepared pulp and, in general, have a high alpha-cellulose content. However, saturating krafts and saturating soda sheets have also been used commercially. The paper is very loosely felted having apparent densities in paper technology varying between 4.0 to 7.50 approximately.

A typical untreated sheet used in saturation of this type was reported by Oliner and O'Neill (*1*) as having the following properties:

	Untreated	*Treated with polyvinyl chloride plasticized 25% B-16*
Bursting strength, p.s.i.	11.0	69.0
Tensile strength, kg.	1.60	10.0
Elongation, %	3.30	5.4
Tear strength, g.	107.00	416.0
Basis weight (25 × 40—500)	216.00	262.0
Thickness, mils	42.0	40.0

Theoretically any sheet of paper is capable of being saturated either by physical adsorption as in water-vapor-paper interfaces or by a liquid medium where the size of the molecules of solvent or solute are no greater than the spaces between the fibers or a group of fibers. To penetrate the intermicellular spaces, the molecular diameters of the solute could only be slightly greater than the sizes of simple molecules. It has been reported (*2*) that the intermicellar spaces are in the order of between 10 to 1000A units or between 0.001 to 0.1 mu. From these data, one can visualize that the molecular size of the solute should not go much beyond ten times the size of simple monomeric molecules, if average success is desired.

Now—superimpose upon this difficulty, problems of wetting and spreading where the work of adhesion to paper must exceed the work of cohesion between the solute molecules; problems of intermolecular electronic forces between the solute and solvent, and between the residing polar groups on cellulose and solute-solvent and adding all this to the new problems of saturating from an emulsoid or a suspensoid which can involve, in addition, ionic mobilities and diffusion, ionic exchanges and possible intramicellar reactivity, physical differences in capillarity between the water phase and suspended phase, orientation of soap at the liquid-paper interface, etc. If one can see saturation in this broad sense, one should be able to understand that the theory of saturation involves more than the simple procedure of dipping a sheet of paper in an emulsion.

Let us narrow the discussion down to a treatment of paper with a resin or rubber latex. It is unfair to discuss natural latex in comparison to synthetic latices since the natural latex system is so unlike any of the synthetics that reading from a list of data can result in misinterpretations of the physical effects observed.

We can start with the disperse rubber or resin phase. While Oliner and O'Neill did a fine job of reporting the results of resin-rubber-paper combinations, resins and rubbers in paper should not be compared for their physical strength qualities without regard for the flexible nature and inherent extensivability of the polymer used.

A rubber or even a rubberlike material is not obtained simply by adding a plasticizer to a resin phase. The strength and flexible properties of a given plasticizer and given resin mix are entirely dependent upon the choice of plasticizer, the concentration of the plasticizer, and the permanency of the plasticizer. Compatibility

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with vinyl resins is obtained by one or more solvating centers in the plasticizer, such as carbonyl, ester carboxylic, phosphate, nitrile, or amide groups. Aside from the observed fact that physical results differ with amount and type of plastizicer, it should be noted that all of the principal solvating centers of the plasticizer are capable of forming H bonds with the residual hydroxy groups of cellulose which will compete in age with the solvent compatibility of the plasticizer for the resin. In addition, any existing "unsaturated" bundles of chain cellulose molecules might behave as a distribution membrane, gradually taking away some of the plasticizer from the solvated resin.

As the resin-latex dries, a loose, random network of resin particles forms around the fibers of paper. If the intermolecular forces of the resin particle, as it forms, are substantially great enough to overcome any or all adhesive forces, the resulting resin-paper sheet will show poor bonding. Pronounced and prominent members of polar substituents, such as Cl^-, Br^-, $COOR^-$, CN^-, yield polymers of high-intermolecular cohesion which are very likely to show poor adhesion to the paper fibers unless the intermolecular forces are weakened by the introduction of polar plasticizers. Under such conditions of diminished cohesion, lateral adhesion between particles takes place as well as between particles and fiber.

One of the factors, therefore, which should be considered in selecting a rigid resin for paper saturation is the structural nature of the resin, but even greater care should be given to the plasticizer. The problems may be broken down as follows:

1. Chemical structure and orientation of groups at the resin-fiber interface.
2. Compatibility between resin and plasticizer.
3. Permanency, e.g., volatility; solubility; migration; chemical stability to light, heat, etc.
4. Plasticizing efficiency at normal and subnormal temperatures.
5. Odor, taste, and toxicity.
6. Cost and availability.
7. Flammability, color, and resin stability.

Considering the saturation with rubberlike materials, namely polychloroprene, polybutadiene, co-polymer styrene-butadiene (GR-S), co-polymer acrylonitrile-butadiene (Buna N), etc., a mechanistic interpretation is confused by variations in soap content between commercial preparations, slight differences in particle sizes, and the effects due to inherent flexibility of a given polymer over another. However, trends are significant and correspond to the theoretical aspects already given.

Polychloroprene invariably gives the stronger sheets from the standpoint of tensile strength, due to strong intermolecular cohesion, but for the same reason lateral adhesion to the fibers is poorer than the other rubbers mentioned. The chlorine atom on every fourth carbon is sufficient to make a noticeable difference. While Mark (*3*) reports that the molar cohesion of polystyrene is about four times that of polyisoprene, the prominence of butadiene residues in GR-S is sufficient to diminish the cohesiveness so that a flexible rubber is obtained showing fair adhesion to paper which decreases as the styrene ratio increases. The adhesion of GR-S to paper is inferior to a plasticized polyvinyl acetate, for example, since there is an obvious absence of strong polar groups in GR-S, except for residual unsaturation in the co-polymer. It is probable that the electron density around the unsaturation is sufficient reason to expect some loose valence bonding between rubber particles and paper.

Buna N shows some interesting behavior. Here is a good example of a polar group—the nitrile radical—which ordinarily shows strong intermolecular effects—diluted by the presence of butadiene residues and redirecting residual electronic behavior possibly toward the paper fiber. The effect is observed nevertheless when rubber and fiber are present in equal proportions and a comparison drawn up between the physical effects of various rubbers.

Summarizing, the author has tried to postulate a notion on the behavior of rubbers and resins in paper and while it contains many omissions and the need for many corrections, it has answered some of the questions regarding obvious differences in rubber saturants. The ideas stress the structural features of the polymers as responsible for adhesion to fiber. It was not intended that the effects of soaps, wetting agents, and the like are without significant importance, and it is admitted that adhesion can be altered by the orientation of fatty acid molecules at the paper interface.

All this sounds very theoretical to the paper converter, but the time has come when the approach to problems must exceed a trial-and-error method. The theoretical aspects find some support in a paper published by A. D. McLaren (*4*).

DeBruyne in 1939 described his adhesion rule as follows: "Strong joints can never be expected to polar adherents with nonpolar adhesives or to nonpolar adherents with polar adhesives."

Josefowitz and Mark in the *India Rubber World* 1942, considered adhesion as being favored by presence of plasticizer and as being inhibited by cross-linking, gelation, and crystallization of the high polymer.

Quoting from McLaren's paper on the adhesion of high polymers to cellulose, he said, "An investigation of the adhesion of polymers to cellulose must of necessity involve an intricate composite of physico-chemical factors including cohesion, surface tension, wetting and absorption, molecular orientation, intermolecular forces, nature and spacings of chain substituents, tensile strength, elasticity, and certain electrical properties, all operating under various conditions of temperatures, humidity, and light."

Prior to the war the paper converter customarily used natural latex as the sole saturating medium. Latex still commands the general interest of the paper technician if only for its unusual combinations of physical and chemical properties. Notwithstanding this acknowledged condition if we decide to utilize natural latex, we must be prepared to accept the nonuniformity of the system, problems of stability, ageing, odor, and possible discoloration. The successful employment of natural latex requires constant attention to these ever-present variables.

During the war, reclaimed dispersions of rubber and plasticized polyvinyl acetate were used extensively for the saturation of paper in the artificial leather industry. Reclaimed dispersions showed poor film adhesion, poor color, poor stability, and inferior physical properties in general. Plasticized polyvinyl acetate gave every indi-

cation of being a suitable saturant provided the technique for improving the low temperature flexibility and prevention of migration of plasticizer could have been found. A multitude of plasticizers have been evaluated for fiber-polyvinyl acetate combinations, but either through migration, adsorption, or volatility, the results have been disappointing. The measured stiffness of sheets plasticized with dibutoxy-ethylphthalate aged at 78°C. for 168 hours increased by 65%; triethylene glycol di-2-ethythexoate by 120%; tributoxy-ethyl-phosphate by 60%; butyl-phthalyl-butyl-glycollate by 135%; and dibutyl phthalate by the phenomenal amount of 770%.

The problems of the development and research man in the paper saturation field are just beginning and are multiplying rapidly. The ever increasing number of new synthetic co-polymer latices introduces new fields, but simultaneously new problems. The past is a reality to be considered critically at the present, and yet the future holds out challenging opportunities.

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Asbestos Cement Pipe for Overhead Piping Systems

CARL W. ZIEGENBUSCH

Typical manufacturing methods practiced for asbestos cement pipe, a description of a few of the successful couplings used, a brief listing of popular fittings, and the practices followed and results obtained in using this pipe in overhead services in the Chillicothe Division of the Mead Corporation are covered in this paper. Description of how the pipe is threaded and flanged as well as the most important details of installation are particularly stressed. When and why connections other than the screwed flange are used. When to use asbestos cement pipe and when not to use it. Conclusions reached as to the continuing use of this kind of pipe and flanged coupling.

The application of asbestos cement pipe for overhead piping systems has presented some very interesting problems and much has been learned from practical application that should be useful to those mills who have been or are contemplating the use of this type of pipe. The author will endeavor in this paper to point out those practices which have given a workable overhead asbestos cement pipe system.

A brief description of how most of the asbestos cement pipes are made would be helpful in the understanding of the problems involved. Asbestos cement pipe is a combination of selected asbestos fibers and cement. Water is added to the thoroughly mixed cement and fiber to form a stock having a low consistency. The stock is then run into a cylinder vat where a continuous web of asbestos fiber and cement is formed on the cylinder mold. The web or sheet is couched off the mold onto a continous felt which carries it over suction boxes and through a press section removing excess water and finally delivers the sheet or web to a polished steel mandrel onto which the web is run to form the pipe. Pressure rolls are continuously run against the mandrel to consolidate the web and insure a dense, homogeneous, strong pipe. As soon as the pipe is formed, the mandrel is removed from the forming machines, a new mandrel positioned, and the operation repeated. The pipe is stripped from the mandrel and placed in cradle cars which are held on the floor for several hours to give the cement an opportunity to take its initial set and gain strength. The pipe, still loaded on the cars is run into the steam curing tanks where it is subjected to a continuous bath of high-pressure saturated steam for a sufficient time to thoroughly cure the cement in the pipe.

From the curing tanks the pipe is fed in automatic lathes where it is trimmed to length and the ends machined to receive a coupling, if required. Every length of pipe in sizes through 8 inches is then given a flexure test and all pipe, regardless of size, a hydraulic pressure test before it is shipped. The hydraulic test is at four times its labeled working pressure. For example; Class 150 pipe is given a 600-pound hydraulic test. Each pipe is then stencilled for class identification.

COUPLINGS

Many different types of couplings have been used for the putting together of asbestos cement pipe in overhead piping systems. Since the author is really familiar with but a few of these he will discuss only briefly those others which have had considerable commercial use in the pulp and paper industry.

The Simplex Sleeve coupling is in general use for underground pipe lines and has, over the years, proved to be quite satisfactory, both from a standpoint of performance and installed cost. It consists of an asbestos cement sleeve, identical in composition to the pipe, which is forced over two rubber rings, effecting a tight joint by compressing the rings between the sleeve and the machined ends of the pipe. Because of the inherent flexibility in the coupling and low resistance to longitudinal tension, it is not generally used for overhead piping systems as it would require an excessive amount of anchoring to resist thrusts created by internal water pressure. In underground systems this resistance to movement is provided by the earth backfill. These couplings are extremely useful to fulfill specific services in overhead lines. More of this later.

The Tee-Tite coupling is one of the first couplings developed for connecting asbestos cement pipe in over head pipe systems. It is a practical coupling which has been used extensively in the pulp and paper industry.

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The coupling consists of two split bushings which are engaged by ring flanges. Bolting the flanges together exerts pressure through the split bushings to compress the Tee gasket between the pipe ends to effect a seal.

The poured-flange coupling, a sleeve-type of coupling that is poured in place with a sulphur base compound, has been used quite successfully for a number of years by one of the large pulp and paper producing units in this country. This coupling never gained popularity because of difficulties encountered in pouring it in place. There were also other mechanical difficulties that most mill engineers did not wish to assume. However, several years ago an engineer in one of the Michigan mills developed a cast, flanged coupling that was applied over the grooved, rough working barrel of the asbestos cement pipe and was held in place by pouring a sulphur base compound into the space between the pipe and the flange casting. After watching the successful operation of this flange for about two years others became interested and made certain changes in design that in their opinion simplified the coupling and widened its application considerably. The results are that today two designs of poured flange couplings are being offered to the industry. Basically both couplings make use of the same principle. These two couplings are known as the poured cast-flange coupling and the Crown Zellerbach poured flange coupling.

The threaded cast-iron flange coupling—this coupling is one which has been used by the pulp and paper industry for a number of years. It provides a good strong joint and, since after flanging it can be erected in the conventional manner it is favored by pipe fitters and erectors. The details of the threaded flange coupling developed and used with great success by the Mead Corp. will be covered later in this paper.

FITTINGS

Many different kinds of fittings have been used for overhead piping systems in the pulp and paper mills. The metal used in the fittings has depended largely upon the type and grade of pulp and paper being made. Several fabricating shops are furnishing fittings for asbestos cement pipe made from stainless steel, copper and other metals. In some very special cases rubber-lined or resin-coated metal fittings have been used. In most cases the author has used standard 125-pound cast-iron flanges.

INSTALLATION METHODS

Considering the actual installation methods as practiced by the Mead organization, in general, flanged asbestos cement pipe is used for overhead service. The individual sections of pipe are first turned down in diameter on the ends, threaded, cast-iron flanges are screwed on, and the sections are bolted together with a suitable gasket between each joint. The principal reason for removing a section of the pipe exterior is to get rid of the softer pipe surface so as to have a stronger thread.

Threading the Pipe

The pipe used ranges in wall thickness from about $^1/_2$ inch for 4-inch size to about $1^3/_4$ inches for 24-inch diameter and is 150-pound pressure pipe. As much standardization as possible in depth of threads and number of threads per inch has been followed. From 4 through 12-inch size the depth of thread is 0.133 inch and the number of threads per inch is 6. From 14 and including 24-inch size the depth of thread is 0.160 inch and there are 5 threads per inch.

The shape of the thread, as turned, is somewhat of a modified, straight screw thread but formed so as to provide a flat at the crests of the threads. This flat is provided to eliminate the small, sharp triangle of material at the outside of each thread which section of material would be structurally weak and would be most likely to crumble when the flanges are screwed on.

Method of Threading

The asbestos cement pipe purchased has plain ends. The first thing done after a length is centered in the lathe is to take cuts off the outside of the pipe extending back from the end a certain definite distance for each pipe size. This length of cut depends upon the distance through the cast-iron flange hub which will be used.

As indicated above, all threading is done on a lathe using a carboloy-tipped cutting tool. This operation is not a difficult one but it does require a certain amount of practical experience to obtain the best results. Figure 1 gives details of the setup in the lathe.

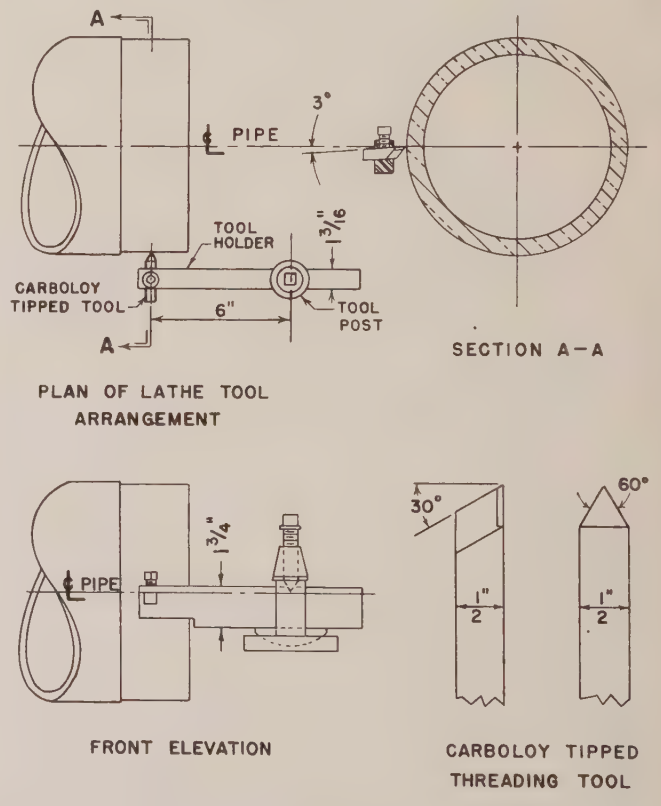


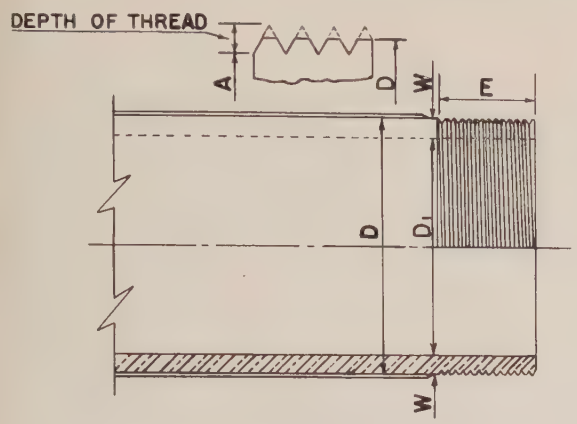
Fig. 1. Class 150 asbestos cement pipe details of threading tools

The final depth of cut is obtained by progressive cutting with not too deep a cut on any one pass. Eight to fifteen passes are recommended for any one threading operation. A cutting speed of about 185 f.p.m. has been found best. A wire brush is used in cleaning up

the threads during cutting. Figure 2 gives details of threading and dimensions of class 150 asbestos cement pipe.

Cast-Iron Flanges

Cast-iron flanges used for asbestos cement pipe follow the standard dimensions for 125-pound cast-iron



A = DIA. AT ROOT OF THREADS
D = FINISHED OUTSIDE DIA.
D_1 = INSIDE DIAMETER
E = MIN. THREADED LENGTH
W = MINIMUM THICKNESS

DIMENSIONS				THREADING DATA			
NOMINAL PIPE SIZE	D_1	D	W	NO. OF THREADS PER INCH	DEPTH OF THREAD	A	E
4"	4.00	5.000	.50	6	.133	4.750	2.00"
6"	5.85	7.055	.60	6	.133	6.799	2.25"
8"	7.85	9.255	.70	6	.133	9.000	2.50"
10"	10.00	11.680	.84	6	.133	11.442	2.75"
12"	12.00	13.940	.97	6	.133	13.703	3.00"
14"	14.00	16.230	1.12	5	.160	15.940	3.00"
16"	16.00	18.470	1.23	5	.160	18.180	3.25"
18"	18.00	20.750	1.37	5	.160	20.460	3.50"
20"	20.00	23.030	1.51	5	.160	22.740	3.75"
24"	24.00	27.610	1.80	5	.160	27.320	4.00"

Fig. 2. Class 150 asbestos cement pipe dimensions and threading data

flanges for pipe size 4 through 24-inch diameters insofar as the following are concerned: outside diameter of flange, thickness of flange, length through hub, diameter of bolt circle, and number and diameters of bolt holes.

However, special flanges with the outside diameters of the hubs larger than standard and bores to correspond to the asbestos cement pipe sizes had to be used which measures were necessary because of the larger outside diameters of asbestos cement pipe. Details of flanges have therefore been made and they are bought as specials.

The cast-iron flanges are threaded to specifications as shown in Fig. 3. When such a threaded flange is screwed on the end of a corresponding size of threaded asbestos cement pipe a very tight fitting flange is obtained. This is extremely important and if the pipe is threaded to the specifications set forth in Fig. 2 and the flanges according to Fig. 3 the flange will fit tightly.

Mounting of Flanges on Pipe

In covering details of flanges it was stated that larger than standard hub diameters were necessary on these because of the larger asbestos cement pipe outside diameters and because of the necessity of using standard bolt circles. This fact makes necessary the reversed installation of the flange on the pipe to that when used with steel pipe. There just isn't room for the nuts on the pipe bolts when installed in the ordinary position. Flanges are screwed onto the pipe while it is still in the lathe. They are run on very solidly and the bolt holes lined up, one flange to the other.

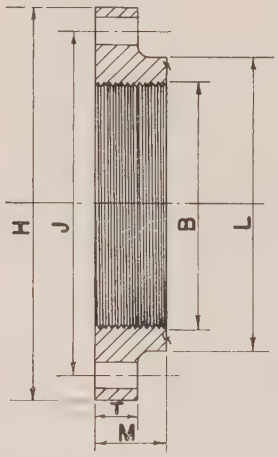
After the flanges are screwed onto the pipe a light cut is taken across the ends of the pipe and flange to assure a finished end.

The pipe is then ready for use.

Bolts longer than those used with conventional flanges are necessary for use with asbestos cement pipe when flanged in this manner. Figure 4 shows these bolt dimensions.

THE USE OF FILLER PIECES

For filling in lengths of comparatively short sections, pipe has been used without attaching any flanges.



FLANGE THREADING DATA			
NOMINAL PIPE SIZE	NO. OF THREAD PER INCH	DEPTH OF THREAD	B
4"	6	.133	5.016
6"	6	.133	7.065
8"	6	.133	9.266
10"	6	.133	11.710
12"	6	.133	13.970
14"	5	.160	16.260
16"	5	.160	18.500
18"	5	.160	20.780
20"	5	.160	23.060
24"	5	.160	27.640

B = DIA. AT ROOT OF THREADS
M = DEPTH OF HUB
J = DIA. OF BOLT CIRCLE
L = HUB DIAMETER
H = OUTSIDE DIAMETER
T = THICKNESS

FLANGE DIMENSIONS							
NOMINAL PIPE SIZE	H	T	M	J	NUMBER OF BOLTS	DIA. OF BOLT HOLES	L
4"	9	.937	1.312	7.50	8	.750	6.125
6"	11	1.000	1.500	9.50	8	.875	7.875
8"	13.5	1.125	1.750	11.75	8	.875	10.188
10"	16	1.187	1.937	14.25	12	1.000	12.500
12"	19	1.250	2.125	17.00	12	1.000	14.610
14"	21	1.375	2.250	18.75	12	1.125	17.010
16"	23.5	1.437	2.500	21.25	16	1.125	19.250
18"	25	1.562	2.687	22.75	16	1.250	21.530
20"	27.5	1.687	2.875	25.00	20	1.250	23.750
24"	32	1.875	3.250	29.50	20	1.375	28.125

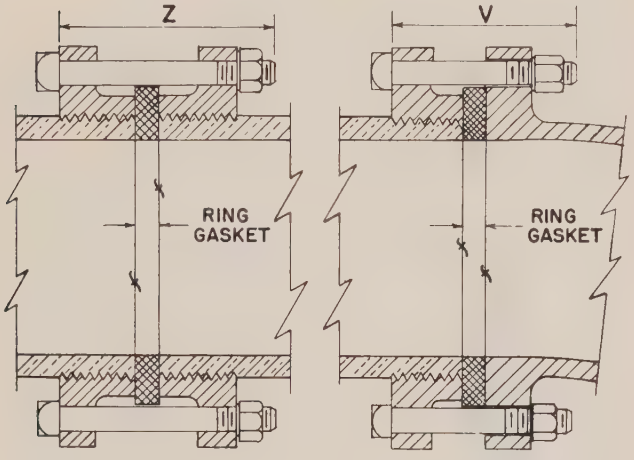
Fig. 3. Class 150 asbestos cement pipe cast-iron flange data

By the use of long bolts between flanges on pipe lengths adjacent to these short sections the joints are pulled up sufficiently to insure a tight line, A rubber ring gasket has been used at each end of the short section of pipe which is unflanged and this procedure has been satisfactory.

THE USE OF SIMPLEX SLEEVE COUPLINGS WITH RUBBER RINGS

A Simplex sleeve coupling has been used for attaching asbestos cement pipe into a concrete chest. The Simplex coupling itself is grouted into the chest opening and then the asbestos cement pipe is inserted in the coupling.

This has proved out very well in the case of pump suctions into concrete chests as well as into tile chests. The rubber rings which make the seal between the inside of the Simplex coupling and the pipe insert serve to take up any shock or vibration which may be present. In case any accident should happen to such a pipe insert in a chest it is quite easy to replace it providing the Simplex coupling itself is not damaged. No damage has been experienced to a Simplex coupling so installed.



Z = BOLT LENGTH FOR PIPE TO PIPE
V = BOLT LENGTH FOR PIPE C.I. FITTING

NOMINAL PIPE SIZE	NUMBER OF BOLTS	DIA. OF BOLTS	Z	V
4"	8	.625	3.50	3.00"
6"	8	.750	4.00	3.50"
8"	8	.750	4.50	4.00"
10"	12	.875	5.00	4.25"
12"	12	.875	5.50	4.50"
14"	12	1.000	5.75	4.75"
16"	16	1.000	6.25	5.25"
18"	16	1.125	6.75	5.50"
20"	20	1.125	7.25	6.00"
24"	20	1.250	8.00	6.50"

Fig. 4. Class 150 asbestos cement pipe bolt dimensions

The second useful service to which Simplex couplings have been put is the following:

Very often there is a short section of flanged asbestos cement pipe which must be fit between two fixed flanges. Such a section is not only very difficult to install originally, it is also quite difficult to remove should the occasion arise for replacing a faulty or worn out gasket. The use of a Simplex coupling inserted in just such sections eliminates all these difficulties.

BRACING AND ALIGNMENT PRACTICES

Asbestos cement pipe, under any conditions of shock usage, must be adequately braced. This is basic and essential and is due to the very nature of the pipe itself. It is quite impossible to cover adequately this subject in a paper such as this. A great deal has been learned through experience.

In erecting asbestos cement-flanged pipe great care must be taken to insure the pipe is in line and that no strain results in placing it. This means that short lengths which may be placed in position last must be very accurately made to proper lengths.

SUCCESSES AND FAILURES

Most of the pipe-lines are installed and then forgotten but to state that all experiences with asbestos cement overhead lines were happy ones would be false. It is true, however, that any flanged asbestos cement pipe lines have never replaced with any of any other material. It has been necessary to brace lines additionally after they were in place. In other words they had to be fixed as they should have been originally. An attempt has been made to use asbestos cement pipe intelligently with respect to its limitations and its use to satisfy any of the following conditions would not be considered: (1) where the pH of the material to be carried falls below 4.5, (2) where temperatures exceed 175°F., and (3) where the pipe-line might be subject to severe external shocks which are unavoidable.

FLOW CHARACTERISTICS IN ASBESTOS CEMENT PIPE

It is believed that frictional resistance to flow is lower in asbestos cement pipe than for any other pipe used by us which has homogeneous walls. By the use of the expression "homogeneous walls" cement, rubber, and wood-lined pipes, etc., are excluded.

Some interesting facts concerning the use of asbestos cement pipe are the following:

There is about 18,500 feet of flanged asbestos cement pipe in overhead lines installed in the Chillicothe Division.

As many as sixteen 10-inch single flanges or eight complete lengths have been completed by one man in a 10-hour day working on a lathe.

The life of asbestos cement pipe has not been determined as the oldest installations in the plant are but thirteen years old.

Pressure tests of 4-inch size flanged asbestos cement pipe have repeatedly been made to 900 p.s.i. before final failure. The pipe failed by pulling apart back of the flange but the threads did not fail.

CONCLUSION

In conclusion the importance of the following to obtain serviceable flanged asbestos cement overhead pipe-lines are stressed:

1. The flange must fit the pipe very tightly.
2. The ends of pipe and flange hub must be flush.
3. The pipe must be very carefully erected to eliminate strain and it must be braced adequately.

If all of the above conditions are fulfilled, the author can see no reason why any mill will not find flanged asbestos cement pipe as satisfactory as the Mead Corp. has found it.

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Digester Linings for Soluble-Base Sulphite Pulping

E. F. TUCKER

Linings designed for calcium-base cooking rely on the filling of the pores of the brick with precipitates formed from the process for complete shell protection. The linings for soluble-base cooking are not readily made impervious by accumulations in the pores of the bricks and must have a basically different composition. The use of ammonia and magnesia cooking liquor has necessitated some very radical changes in digester linings, including the abandonment of the litharge joint. Linings for sodium, magnesia, or ammonia-base cooking may be almost identical as to specification. Considerable operating information on the effects of cooking liquors made with all these bases is now available. Indications are that good success can be expected from the type of lining now being used in several mills. The lining problem must be considered in relation to over 500 existing digesters, many of which may be converted to soluble-base cooking. The construction of these shells prevents the use of certain types of linings which will be considered for future welded shells. New installations, designed specifically for use with soluble base, may have thinner linings than are now ordinarily used.

DURING the early years of the sulphite pulp industry, lining specifications for the digesters were made substantially on a trial-and-error basis. The first digesters were comparatively small and were of bronze or lead-lined steel. The earliest brick linings of which we have record were installed in 1883. Brick linings were first installed mainly to protect and support the lead linings, and this became general practice between the years 1884 and 1902. Eventually brick linings applied directly to the steel shells practically superseded all other types, and since 1902 brick linings of varying thickness and composition employing a rather wide range of bricks and mortars have, with very few exceptions, been used in all sulphite digesters throughout the world. All types of brick ranging from dense clay and shale acid brick to porous fire clay refractory brick were tried from time to time until the present type of digester brick became generally accepted.

The brick used for linings at present have improved resistance to thermal and mechanical spalling in comparison with dense, highly vitrified acid brick and improved resistance to chemical spalling and chemical attack in comparison with the more porous and less vitrified fire clay refractory brick. Digester brick then have been somewhat porous since a certain minimum degree of porosity accompanies other necessary properties. Since calcium has been the base in the preparation of bisulphite cooking liquor for the sulphite process, it has been only natural that the development of linings for digesters has conformed to the special requirements and peculiarities of the calcium-base process. Brick having a certain degree of porosity can be tolerated because the pores of the brick are soon filled with precipitates of calcium salts so that little or no permeation of the acid liquor takes place through the lining. The bond between particles in the brick has been maintained great enough so that chemical spalling has not generally been of serious concern during the early life of a lining and has been noticeable only after many years of service.

The use of magnesium and ammonium bases first began to attract wide attention in the early 1920's. Many references to the use of soluble bases can be found in the literature for this period, but little or no mention was made of any special lining requirements. Observations on linings made by certain operators using Dolomite or high magnesia lime in milk of lime systems contributed some private information during this period, but there was no general interest in linings for soluble-base liquors. Problems encountered when using sodium base during the 1930's were obscured by the secrecy surrounding experimental work with this base and its commercial use in a few mills. Experience gained in mills using mixed or alternate sodium- and calcium-base cooking liquor was virtually useless from the viewpoint of lining requirements because of inconsistent operations and periodic changes whereby the conditions to which the linings were subjected were indefinite. Concern for the linings was of course secondary and therefore was postponed, at least until cooking procedures were established.

The first specific demand for digester linings which would be subjected to soluble-base sulphite cooking was made in 1940 when magnesium-base sulphite operations were projected. With the sudden adoption of ammonia as a base for large tonnage production in 1945, it became obvious that lining requirements for digesters operating with soluble-base cooking liquor were definite and of appreciable engineering and economic importance.

LININGS FOR CALCIUM-BASE PULPING

For the past 15 or 20 years the linings for calcium-base sulphite cooking have been mainly of two standard types which are installed in over 90% of the sulphite digesters in North America. These two types are the so-called single course or thin lining, and the double course or double laid type. Thin linings generally consist of a face course of $2^1/_2$- or 3-inch brick laid with a litharge-glycerine cement joint, and between this lining and the steel shell is placed a Portland cement concrete bonding wall. Total thickness of the thin type of lining varies from 4 to 6 inches. The double course linings consist of a face course of 3-inch brick and a backing course of 2-inch brick, both laid in litharge-glycerine cement with a Portland cement concrete placed between courses and between the backing course and steel shell. Total thickness of the latter type of lining is usually $7^1/_2$ inches. The thinner linings are generally placed in

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the smaller digesters and are frequently favored where shells are old and of doubtful strength requiring complete lining removal at the time of each replacement. The thicker type lining is preferred for the larger digesters and where a longer cycle between lining replacement is desired. For such linings it is usually necessary to replace the face course leaving the backing course for two or three face course replacements.

Linings of these types have consistently given very satisfactory service. The use of very high acid-strength liquors and unusually severe operating conditions have in a few instances made it advisable to use a denser and more acid-resistant brick at some sacrifice of thermal spalling resistance, but there has been no apparent need for a general change in digester lining specifications for calcium-base sulphite cooking. The installation of thinner linings and the elimination or reduction of Portland cement grout are possible for welded shells, but the number of these may be comparatively few, at least for many years to come.

REQUIREMENTS FOR DIGESTER LININGS

The advent of sodium, magnesium, and ammonium-base cooking poses a different problem. Since the use of soluble bases did not receive extensive consideration until recent years, the problem of lining specifications had not been given consistent attention. Where soluble-base sulphite liquors had been used previous to 1940, the conditions were considered as specific in each instance. The problem at each location was approached differently in accordance with those conditions and in accordance with the reasoning of various individuals in each case. It is now indicated that the use of soluble-base sulphite liquors will increase beyond the present substantial volume.

Digester lining specifications for soluble-base sulphite cooking are problematical because the deposition of pore filling material in the brick is very much slower and less complete than is the case with calcium-base sulphite cooking. In fact, practically no inorganic material is deposited from the soluble-base liquors, and what pore filling does take place results from the separation of pitch and other organic material. This means that permeation of acid liquors to the readily attacked Portland cement is likely to be excessive, and the amount of permeation is not likely to be sufficiently reduced even after several months of operation. The danger of attack on the backing and shell as a result of permeation is accentuated because the total acid strength of the soluble-base liquors in the processes recently put in use are higher than the acid strengths of most calcium-base liquors.

Perhaps the first item in the lining to consider is the brick. The use of a very dense brick would be very effective in reducing or eliminating permeation, were it not for other adverse factors. First, the amount of thermal spalling would frequently become excessive. Second, the bond of all mortars with brick is practically proportional to the absorptiveness of the brick and with highly vitrified brick is virtually negligible. The tendency for a lining to crack, if and when it is placed in tension, would therefore be much greater, especially at the mortar joints. Third, if differences in the thermal conductivity and thermal expansion characteristics of the brick are not taken into consideration and properly compensated for, the chances of a lining being placed in tension become greater. Full consideration of these factors results in a limitation of brick properties.

The next step in designing the new type of lining was to carefully review a study which had been made of temperatures existing in the lining of an operating digester. This work had been undertaken to check, once more, various theoretical and practical assumptions which have governed the design of calcium-base linings and insure their proper application to the new problem. Temperatures were taken by means of thermocouples placed in wells at various depths in the lining and in various sections of the lining. Continuous temperature records were obtained at a total of sixteen locations during four 1-week periods at 6-month intervals during the first two years following the installation of the lining. The results enabled the checking of theoretical calculations which have been made from time to time, and enabled close estimation of temperature gradients for digester linings in general. It has always been realized that the success of a lining depends on the balancing of all factors, some of which are quite as important as the more obvious ones such as density and inertness of the brick.

In considering the digester lining specifications for soluble-base cooking, the following factors must be considered:

1. Chemical resistance and chemical spall-resistance of the brick and other materials.
2. Permeability of the materials.
3. Bond strength between brick and mortar joint.
4. Bond of the face lining with the backing or bond of the lining to the shell.
5. The compressive strength and mechanical spall-resistance of the brick and other materials.
6. The thermal spall-resistance of the brick and other materials.
7. The thermal conductivity of all the materials and the temperature gradients through the lining.
8. The thermal expansion of the lining and the digester shell.
9. Type of shell, design, and construction.
10. Lining materials and workmanship.
11. The operating temperatures, cooking cycle, and operating practices.
12. External conditions.

EFFECT OF TEMPERATURE CHANGES

Therefore, when any major change in materials or in lining thickness is desired, it must first be determined if any adverse effects accompany the particular beneficial effects gained. A change in lining thickness, for instance, might change shell temperatures and temperature gradients in the lining to such an extent that the bricks are placed in greater compression resulting in greater mechanical spalling. Conversely, shell temperatures may become so high that the resulting expansion of the shell would be greater than that of the lining, leaving the lining in tension. It should also be realized that the heat flow through a lining never reaches a steady state. The experimental work referred to above showed that in a 14-foot diameter digester having a $5^1/_2$-inch single course lining operating on approxi-

mately a 9-hour cycle, the over-all average temperature of the brick varied by 100°F. while the shell temperatures varied by only 25°F. during normal operations. Also, it was found that the temperature on the face of the brick might be lower than the shell temperature for from $1^1/_2$ to 2 hours during each cooking cycle, while at the temperature peak of the cook a difference of almost 150°F. between face brick and shell might exist Obviously, also, the sharpest temperature changes occur in the face brick and temperature changes become the more gradual with distance from the lining face. For the greater part of each cycle, the temperature gradient beyond the face $1^1/_2$ or 2 inches is comparatively low, and a break or major change in slope of the temperature curve occurs at a point equivalent to a point in the face brick. In the particular case referred to the maximum or steepest temperature gradient in the lining as a whole at all levels seemed to occur at about the fifth hour of the cook. Before the fifth hour the back and the interior of the lining were found to lose heat after the previous cook faster than they gained heat, and after the fifth or sixth hour the temperature of the lining as a whole was found to rise faster than the temperature on the face of the lining, the latter having approached a maximum.

Shell temperatures also vary with the surrounding air temperatures. To a lesser extent, depending on distance from the shell, the lining components are also affected by surrounding air temperatures. Temperatures on the shell and in the back of the lining would normally be expected to be lower and the temperature gradients sharper during the colder seasons. Drafts or air currents, especially, might cause a severe reduction of shell temperature. If such drafts involve outside air which is relatively cold, an exaggerated condition would exist. The effects of drafts or air currents may be more pronounced than a change in the surrounding air temperature. Thus, it was found that a shell temperature reduction of over 25°F. was obtained by means of a 10 foot per second (7 m.p.h.) draft, the air being circulated without the introduction of air colder than the normal surrounding air. Assuming an installation temperature of 75°F., this means that the expansion of the steel shell would be reduced by one-third in locations affected by even a mild warm air current.

These considerations have been mentioned to emphasize the interrelationship of many factors, so that it can be realized why there might be some hesitancy in taking steps which might superficially seem obviously desirable. The special problems attending the design of digester linings for soluble-base sulphite cooking are additional to those which have been solved for calcium-base operations. These special problems have to be solved without neglecting or seriously compromising those requirements which experience with calcium-base cooking has shown to be essential. The position is sometimes all the more difficult because all of the effects of the several factors cannot be thoroughly investigated and are not completely understood. Considerable operating data are now available on linings which have been in service in soluble-base sulphite pulping. Specifications can now be prepared with reasonable confidence and the indications are that good success can be expected from the type of lining now being used in several mills. Linings for sodium, magnesium, and ammonium-base pulping may be practically identical as to materials, thickness, and method of construction.

SOLUBLE-BASE LININGS

The lining problem must, of course, be considered with reference to over 500 existing digesters, many of which may be converted to soluble-base cooking. More than 400 of these digesters have a probable remaining life in excess of 25 years each. It is therefore apparent that the problem of fitting linings to these existing digesters is of immediate importance. The construction of these riveted shells prevents the use of certain types of linings which will be considered for future shells of welded construction. The recommended installation for a riveted shell consists of a double laid lining. The backing consists of 2-inch brick laid with a litharge-glycerine mortar joint and bonded to the shell with 2 to $2^1/_2$ inches of poured Portland cement concrete. The face lining consists of 3-inch brick laid solidly with a resin-base cement directly on the backing brick. The chemical inertness and the impermeability of the resin-base cement will contribute to a good degree of permanence and a long service life. Permeation of the acid liquors through the layer of resin cement behind the face brick has been found to be practically negligible and occurs only where cracks develop in the resin-cement layer. Permeation of liquor through each crack is stopped at the backing brick so that no disintegration of the Portland cement backing grout takes place.

In welded shells the linings may be thinner and the Portland cement backing may be completely eliminated. In this case there are no inside butt straps with which to contend. In riveted shells the only economical method of providing an even surface for the brick lining proper is by use of a Portland cement grout. The straps must be covered with a minimum required lining causing an added thickness equivalent to the strap plus whatever rivet clearance may be required. The changes in thickness which occur at every strap also have to be taken into consideration when the lining is made as thin as possible, since cracking may occur as a result of high-unit compression. There is then at least that one important difference between welded and riveted shells in connection with the linings. Welded digesters have been in use in Scandinavia for many years. On this continent a number of horizontal units have been built, but the first vertical shells of welded construction are only now being fabricated for a new plant.

Lining installations for such welded shells may consist of a protective rubber or synthetic-resin membrane placed directly on the shell followed by a double laid brick lining consisting of a 2-inch backing and a 3-inch face lining, both laid solidly with a resin-base cement. The total thickness of these linings would be approximately $5^1/_2$ inches. Such linings of uniform thickness over the entire area will probably give a longer average service life than those of $7^1/_2$-inch thickness presently used for calcium-base operations. The actual cost, especially on a pulp tonnage basis, should not be greater than for calcium-base pulping. However, the operating methods which prevail in the sulphite mills of North America must be altered to eliminate those severe

shocks, stresses, and operating conditions which now make such linings impractical.

The use of soluble bases may be accompanied by a complete revamping, renewal, or replacement of the recovery system. Closely controlled operating conditions and cooking processes modified to save heat usually contribute to the reduction of shocks and uneven stresses in the linings. Uniform operations and uniform lining thicknesses throughout the digester should be among the greatest factors in reducing spalling during the early life of a lining. It is well understood that the types of spalling which sometimes occur during the early life of a lining are thermal and mechanical. Chemical spalling is usually secondary and takes place only after the brick have been weakened by chemical attack over a period of years. If mechanical stresses and heat shocks can be reduced or controlled to a greater extent, then it will be possible to use a slightly harder, denser, and more vitrified brick which would be more resistant to chemical attack and subsequent chemical spalling. In any event it can be expected that the service life for digester linings for soluble-base sulphite pulping should be equivalent to the service life for calcium-base sulphite pulping, whether or not such linings are installed in shells of riveted or welded construction.

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Use of Beater and Headbox Additives for the Improvement of Sheet Characteristics

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Materials proposed for addition to pulps and to papermaking furnishes for the improvement of sheet characteristics are listed and their performances compared. A critical survey of recent literature discloses many contradictory results emphasizing the need for further investigations in this field. The special topic of additives for the improvement of wet strength is not covered since interest in this problem has led to the recent comprehensive literature survey by Adrian and Collins (*34*).

Many substances have been proposed for beater or headbox addition which will improve the finished sheet. It is postulated that such a substance will permit achievement of a given strength at a lower degree of refining and therefore reduce power requirements and allow faster operation because of better drainage. In addition, less beating forms a less dense sheet resulting in less curling and less two-sidedness. Strength improvement would permit the use of higher percentages of inert fillers and weak short-fibered filler pulps, thus conserving the critical supply of long-fibered pulps. Many other claims for a superior product can be found. However, the entire picture is confused by contradictory results and inconsistent performance of the active materials.

Interest in this field was manifested at the Annual Meeting of the Maine-New Hampshire Section of TAPPI which was held June 17 and 18, 1949 (*30*). Several papers dealing with wet end additives were delivered including "Use of Gums and Mucilage as Beater Additives for Papermaking" by John W. Swanson of the Institute of Paper Chemistry and three papers by representatives of Rohm and Haas, Nopco, and Monsanto. An informal panel discussion on the subject attracted more than 80% of those present.

A by no means complete list would include the following materials among those which have received study in recent years: locust bean gum (*1*), guar mucilage (*2*), deacetylated karaya gum (*3*), PLF (a mannogalactan) now called "Lycoid" (*3*), methylcellulose (*3*), carboxymethylcellulose (*4*), Taprosize C (*3*), Tufjel (*4*), latex (*5*), Amberlite W-1 (*6*), soluble starch (*3*), sucrose (*3*), apple pectin (*3*), gelatin (*3*), flax and psyllium seed extracts (*7*), and formaldehyde (*3*).

Before considering the individual materials, it may be well to review the proposed mechanisms of bonding within a sheet. The action by which hydration or pulp development proceeds is generally believed to be physicochemical or colloidal in nature and involves the concept of fiber-to-fiber bonding. The mechanism by which such a bond operates is not well understood. Many theories have been advanced, but there is no general agreement among workers in this field.

Campbell's theory for the formation of fiber-to-fiber bonding is based on the drawing together of fibers by the forces of surface tension as interfiber water is removed (*19*). The forces bring the cellulose surfaces sufficiently close to allow their own crystallizing forces to act on each other and a bond is formed. In other words, forces set up by surface tension cause shrinkage even to the point of introducing stresses in the solid particles and the intercrystalline forces hold the compressed structure together after the liquid is evaporated. This theory is substantiated by the work of The Institute of Paper Chemistry in which handsheets were formed by sublimation of the interfiber water at $-6°$C. so that surface tension forces could be eliminated (*20*). The resulting sheet had lower tensile strength and higher opacity and brightness than a control sheet thus indicating the low degree of bonding between fibers.

Cottrall (*21*), Mark (*22*), and Landt and Rulon (*23*) consider free hydroxyl groups to be responsible for bonding by virtue of their great reactivity leading to union when in intimate contact.

Dixson (*24*) showed that the hydrophilic character of fiber surfaces determines to a large extent the strength of fiber bonding. The strength of handsheets was improved by the addition of hydrophilic agents such as

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gelatin, cellulose gel, and locust bean gum which coated the fibers and increased the number of fiber-to-fiber bonds which could be formed. Conversely, the addition of wetting agents decreased the hydrophilic nature of the pulp and resulted in weaker sheets.

In the light of these theories on sheet formation, let us consider the ways in which beater additives may act. Many of the materials are classified as deflocculating agents, consequently their presence in the beater may bring about more uniform beating and more uniform sheet formation on the machine which may actually result in a greater number of fiber crossings and a consequent increase in fiber-to-fiber bonding. In addition, other agents such as methyl cellulose may aid in the action of fiber-to-fiber bonding by forming an active film. Other suggested effects are modification of the electrokinetic potential of pulp particle surfaces or a change in their hydrophilic character or by a chemical attack on the cellulose itself (*1*).

EFFECT OF AGENTS

A brief discussion of the specific materials mentioned earlier is now in order.

The addition of locust bean gum to pulps was found to give appreciable improvement in both sheet formation quality and strength properties in Institute of Paper Chemistry investigations shortly before the war (*9*). One per cent of locust bean gum beaten with a coniferous sulphite pulp for 20 minutes gave a handsheet of the same bursting strength as that of the pulp beaten alone for 50 minutes; a saving of 60% in beating time. It was found that the addition of the gum to the beaten pulp did not in itself produce much strength improvement.

When the same sheets were tested for tearing strength it was found that the tearing factor reached a maximum with less beating and then dropped to lower values than the untreated sheets indicating that better fiber bonding was causing fibers to break off rather than pull out of the sheet.

Locust beam gum was also added to a Douglas fir kraft pulp and caused significant improvement in bursting strength, tear factor, tensile strength, and fold endurance.

When applied to a hardwood pulp, locust bean gum did not cause any marked rise in sheet strength. Nevertheless, the favorable action of softwood sulphite permitted the formation of a 45% hardwood–55% softwood furnish with 3% locust bean gum that had the same strength as a 10% hardwood–90% softwood mixture.

The favorable effect of gums of this type in improving formation characteristics is partially discounted by the presence of alum and the best results have been obtained in furnishes using little or no alum.

World War II caused the disappearance of locust bean sources from France, Italy, Spain, and North Africa. Guar gum was developed as a substitute.

Guar mucilage is produced by General Mills and has a mannogalactan content which gives it characteristics similar to locust bean gum. The following claims have been made for the use of guar. A book mill reported an increase in speed of 14% with slightly improved formation, bursting strength, and tear resistance and a kraft mill reported a 15% increase in speed, but no improvement in strength characteristics (*2*). The same source stated that for the same burst range the addition of 1% guar required 37 to 57% less development and exhibited 16 to 330% faster drainage. The sheets formed from this pulp had 44 to 76% lower densometer readings and 8% greater fold endurance. When laboratory tests were made by the Institute of Paper Chemistry on cotton linters a real improvement appeared in respect to bursting strength, tear resistance, and fold endurance (*3*). Further experiments by the Institute on coniferous sulphite pulp showed a behavior of guar gum quite similar to locust bean gum. Only one-half of one per cent was sufficient to effect a 50% saving in beating time (*9*). However, other laboratory tests on bleached sulphite pulp revealed no real improvement since the increased bursting strength was accompanied by lower tearing resistance (*3*).

Also in the gum field, deacetylated karaya gum has received some attention. Broadbent and Harrison found that although ineffective in its naturally occurring state, karaya gum became an excellent dispersing agent after deacetylation with ammonia (*11*). The use of partially deacetylated karaya gum for dispersing long-fibered pulps has been patented by LeCompte (*25*). The effectiveness of this agent was confirmed by the work of Wollwage (*8*). Erspamer, in a continuation of the same study, found that locust bean gum and methyl cellulose were better deflocculating agents than deacetylated karaya gum (*26*).

Another material of the mannogalactan type formerly known as PLF has now been named "Lycoid" by its manufacturers, Stein-Hall & Co. Laboratory work with this product resulted in handsheets with good strength characteristics but mill runs failed to establish any definite improvement (*3*).

The cellulose ethers have been successfully used as coating agents. Tests have also been made to determine their suitability as beater additives. Methylcellulose, the methyl ether of cellulose, has received study in the beating of cotton comber noils and was found to make a definite contribution to the strength of the sheet from the standpoint of bursting strength and fold test (*3*). Other experimentation with several methylcellulose samples of different viscosity on cotton pulp indicated practically no strength improvement (*3*). Experimentation by the Dow Chemical Co. with methylcellulose on cotton linter pulp led to the following conclusion (*28*): (1) A sufficient amount of methylcellulose in a sheet leads to a definite increase in bursting strength, folding strength, and tensile strength, the per cent increase being greater with increased hydration. The most striking improvement was a 568% increase in folding endurance at 100 ml. freeness. (2) The high-viscosity methylcellulose was more effective than the low-viscosity product. (3) The retention of methylcellulose was greater when precipitated in the beater by heating or when added in solution rather than dry but rosin size had no effect on retention. (4) Sheet strength was not effected by raising the drying temperature from 70 to 120°C. (5) Sheet strength was decreased when white water containing rosin and methylcellulose was used in beating, when methylcellulose was used with glassine stock, when size was added to the pulp, and when methylcellulose was precipitated in the beater by heating. The Dow Chemical Co. is now working on modi-

fied methylcellulose which they believe may minimize the problems of foaming and retention (*16*).

Musser and Engel found methylcellulose to be the most effective of a number of agents which they tested (*1*). They reported that higher concentrations of the agent gave higher strength sheets. The higher viscosity methylcelluloses were also more effective than their lower viscosity analogues. In their tests with a sulphite pulp they found the increase in folding endurance to be especially significant. A 5% methylcellulose application showed a 1470% improvement in fold (Schopper). The favorable report on methylcellulose is also supported by another study on sulphite pulp in which a marked increase in strength characteristics was found (*3*). Edge reported increased sheet strength after the addition of methylcellulose (*10*). Broadbent and Harrison reported that methylcellulose in excessive amounts gave appreciable fiber dispersion and improved sheet formation (*11*). Dennet established increased strength in sheets containing methylcellulose and found that the high viscosity types made the greatest contribution (*5*). Water-soluble mixed ethers of cellulose have been tried with comparable results.

Carboxymethylcellulose (CMC), used as the sodium salts, was investigated by several groups. One study found that the beating time to reach a given freeness was reduced substantially and strength properties were improved (*3*). Horsey reported increased tensile strength at all degrees of freeness when 5% CMC was added to sulphite pulp and precipitated with alum before sheet formation (*4*). Burst, stiffness, fold, and sizing properties were also improved with a decrease in tear. Edge reported increased sheet strength after addition of CMC (*10*).

Work by the Hercules Powder Co. indicated that low viscosity CMC added at the beater is effective in improving abrasion resistance, fold, ink resistance, and wax pick on both sulphite and soda-sulphite furnishes (*32*). They have also conducted mill trials in which high viscosity CMC was added ahead of the fan pump to improve the formation of papers made from long-fibered stock.

The DuPont Co. reports that several types of sodium CMC may be used (*33*). One grade is said to be a more effective deflocculating agent than natural gums in improving the sheet formation of long-fibered pulps. Modifications of this grade permit improvement of sheet formation with or without strength improvement as desired. Bursting strength can be definitely increased by addition at the beater in both sized and unsized sheets.

Another beater additive is a mixture of highly converted tapioca starch and rosin size known as Taprosize C. It is said to improve strength properties with respect to burst and fold tests and to give a brighter color (*3*). Under actual test, the color requirement was reduced, but strength improvement was not great enough to recommend its use (*3*). On the other hand, other mills evidently found it satisfactory and included the material in their regular furnish.

A special treated starch known as Tufjel is claimed by the Meincke Co. to increase the bursting strength from 20 to 24 on a 16-pound sheet and to increase the folding endurance from 400 to 600 with no loss in tearing resistance (*3*). However, actual use on the machine by one mill demonstrated a desirable effect on filler retention but the strength improvement was not borne out (*3*). Other mills have apparently had very good results from the continued use of Tufjel. Several similar products are made by other manufacturers.

The effect of both natural and synthetic latex have been investigated. Synthetic latex caused greater improvements in handsheet strength (*7*). Synthetic latex presents a special problem in application, possibly due to lack of natural proteins or to the type of emulsifying agents used in its manufacture. DuPont reports that mill runs using neoprene latex have produced sheets with increased dry strength properties as well as very good wet strength (*27*). The sheet had increased folding endurance, a certain degree of chemical resistance, and decreased porosity with little loss in tearing strength. In some cases, simultaneous increases in bursting strength, tearing strength, and wet strength were attained. When Collins used natural latex with a sulphite pulp it caused a 24% increase in burst, a 126% increase in fold, 4% increase in tensile, and a 13% decrease in tear (*5*).

In the resin field, Amberlite W-1 has been tried. As a surface size it increased fold endurance by 500% when used in a 3% application according to the manufacturer, Rohm & Haas (*5*). Further testing on it as a beater additive by Collins showed a decrease in required beating time and it improved strength properties considerably (*5*).

The National Bureau of Standards showed that resin bonds of the melamine-formaldehyde type can be substituted for the gellike bonds which result from the hydration associated with beating (*31*). It was recommended that this resin might be especially useful in offset papers where excessive beating develops a sheet with high curl and expansivity, slow oil absorption, and low opacity. The use of the resin minimized these troubles by permitting development of the required sheet strength with much less beating and also allowed the introduction of filler pulps which do not readily hydrate and therefore contribute to low curl and expansivity and good oil absorption. It was possible to develop a much higher fold resistance without the usual accompanying undesirable effects.

When 2% of the resin was added at the headbox to a 75% coniferous sulphite – 25% soda furnish beaten for $1^1/_2$ hours, the bursting strength and surface pick were comparable to $9^1/_2$ hours of beating without resin addition. When 3% resin was used, the strength was superior to that obtainable by any amount of beating.

When a 75% soda – 25% sulphite furnish was used, the resin bonding gave a higher relative strength improvement than it did with the higher sulphite content. Beating intervals of $5^1/_2$ hours with 1% resin and $1^1/_2$ hours with 3% resin produced paper superior in strength, oil absorption, and curling tendencies to control papers beaten $9^1/_2$ hours.

A 75% deciduous sulphite – 25% coniferous sulphite furnish was also greatly improved by the resin addition. Beating $9^1/_2$ hours without resin was equivalent to $5^1/_2$ hours with 3% resin and $5^1/_2$ hours without the resin produced paper comparable in strength to beating $1^1/_2$ hours with 1% resin.

Soluble starch is, of course, added to the furnish as a sizing agent, but its contributions to the sheet strength

must also be considered. According to Cobb, Lowe, Pohl, and Weiss the strength imparted by starch reaches a maximum at a definite concentration in the sheet which they claim to be 0.5% (*12*). They attribute its action both to a shrinkage of fiber structure resulting in a higher sheet density and also to adhesive powers independent of sheet density. Strasser points out that the starch requirements vary over wide ranges because of the great variety of papers being manufactured, the varied furnishes, and the manipulation of these furnishes to obtain specific qualities (*13*). Casey feels that the chief function of starch in paper is to increase the fiber-to-fiber bond by acting as a cementing agent between adjacent fibers at their point of contact and that, therefore, a highly dispersed starch is more effective in a high density sheet but would be largely wasted in covering the noncontact areas (*14*). He presents experimental evidence to prove this relationship between sheet density and degree of dispersion of starch for maximum effectiveness.

Meincke has a patent for an open-textured high strength paper prepared by the addition in the beater of a readily dispersible specially prepared fine-grained starch (*15*). Another patent by Carson involves improved bonding of material in the web by adding after the beater a finely pulverized mixture of starch gum, sodium aluminate, and iron-free aluminum sulphate (*16*). Rowland points out the difficulties in attaining the best combination of degree of cooking of starch and subsequent beater action on the particles (*17*). He claims that the best control over these variables consists of the addition of a starch, cooked just past the bursting point of the swollen grains, after jordaning. The sheet produced has remarkably good improvement in burst and fold. Alkali-swollen potato starch has been substituted for gumlike additives at the headbox and found to give comparable results at reduced cost when used at twice the concentration of the gum. Strasser believes that the strength factor imparted by starch is in direct relation to the strength of the fiber and for this reason would be of no value to groundwood paper because the fiber itself is of low strength (*29*).

A good example of the lack of agreement on the benefits of starch is found in the TAPPI Special Report on "Starch as a Beater Furnish" (*18*). Many mills reported no effect attributable to the use of starch. However, mention was made of a 19.6% increase in tensile strength when 10% swollen starch was used. When 10% sodium silicate was added with the starch an increase of 27% was observed over the value for starch alone. The work of Musser and Engel mentioned earlier included soluble starch, sucrose, apple pectin, gelatin, flax and psyllium seed extracts, water-soluble methyl cellulose, and formaldehyde (*1*). Gelatin appeared to inhibit hydration but the other materials brought about a pronounced increase in breaking length for any given beating time. Methylcellulose and formaldehyde gave greatest improvement and were given further study. In each case, the additive was ineffective if added to an already beaten stock so the material was added at the beginning of the beating period. The formaldehyde showed increased strength with cotton pulps up to 20% formaldehyde. The tear factor dropped off rapidly as beating progressed. It is suggested that the formaldehyde solutions swell the cellulose and therefore may facilitate the fibrillation and beating process.

Such an array of data leaves little doubt that the subject of beater additives is entitled to further investigation. Several reasons have been suggested for contradictory results.

Methylcellulose causes difficulties due to its foaming characteristics. Foam killers must be added and their surface activity may well be injurious to the sheet. However, the work of Wollwage showed that a wetting agent of the sulphonated alcohol type in 15% concentration caused only a small decrease in the dispersion of fiber (*8*). Another factor which has not been constant in all tests is the ion content of the water. A third variable is the heat treatment in drying of the sheet. Despite the inconsistent behavior of these agents in the past, the advantages which can be realized by their use will continue to serve as incentive for the search for "hydration which can be poured from a barrel."

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Curlated Pulp—A New Approach to Pulp Processing

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A permanent change in the shape of pulp fibers is obtained by causing nodules of high consistency pulp to roll in changing directions between two surfaces which compress the nodules while they roll. The change in shape is toward more bends, kinks, and twists and a more tubular cross section. The manipulation also exerts a powerful deshiving action. The equipment for such is briefly described. The process causes a change in all pulp properties and, while there are many degrees and variations, the effect in general is toward a softer pulp and thus is somewhat opposite from the effect of beating. Freeness tends to rise. In appearance sheets of the treated pulp take on a more even-textured, matte look. The process effect is in evidence applied at any degree of beating, and to some extent persists through subsequent beating. The process effect resembles that of drying in regard to strength properties but differs for stretch, drying tending to lower stretch and the process to increase it strongly. The process widens the range of quality obtainable from a given pulp and also permits entirely new combinations of pulp properties, thus indicating a wide variety of possible application. Among other things, it may permit a higher pulp yield for many conversions.

A word of explanation is in order about the name, curlated pulp. It is a coined term derived from the name, curled pulp, which had been applied to the product during the early development period as a sort of nickname suggestive of one of the dominant characteristics of the treated pulp, namely, a permanent change in the shape of the individual fibers toward more bends, kinks, and twists. As the development work on the new process has progressed, it has become apparent that there are factors and relationships involved which go well beyond considerations merely of fiber shape, yet in the obvious need for a convenient descriptive term, the name, curlated pulp serves perhaps as well as any. It will be used generally in the following discussion to designate pulp which has been treated according to the new process in question, in turn called curlation.

Literature references to the effect of fiber configuration on pulp and paper properties are few and indefinite, and there seems to have been little recognition of any particular significance to be attached to this factor, and no attempts made to isolate the effect and study its relationships. No processes have been brought out for changing the shape of papermaking fibers as an end in itself. In the case of certain textile fibers and the coarser hairlike materials used for upholstery, the art of curling and kinking by various chemical and mechanical means is old and well developed. Highly advanced also, and indeed widely practiced, is the art of curling and waving human hair. When one considers the matter, it seems hard to account for the neglect of this field of technology for fibers used in papermaking.

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It is true that some of the usual pulp processing steps cause changes in fiber configuration incidental to the main effect of the operation. Thus, such steps as blowing pulp from the digester, beating or other conventional refining of the pulp, bleaching at high density, dewatering to high density in a screw press, and pulp drying, all produce varying degrees of deformation of the original straight shape of the fibers. In all these cases, however, the change in configuration has been either too small to receive special recognition or has been masked by other more positive effects of the operation in question.

The present paper describes a mechanical process for imparting permanent bends, kinks, and twists to pulp fibers; it lists some of the many changes which the process can bring about in pulp and paper properties, and indicates general fields of usefulness for the process and for the product, curlated pulp.

The process, in essence, is extremely simple. Nodules of high-consistency pulp are caused to roll in continuously changing directions between two surfaces which compress the nodules while they roll. All the essential requirements of the process may be accomplished on small scale by rolling a nodule of pulp with a circular motion between the thumb and finger and continuing the action for a small part of a minute. Similarly, on a somewhat larger scale the process may be carried out by squeezing a handfull of slush pulp to a consistency of 15 to 25%, placing the lump of dewatered pulp on a suitable tractive type of surface such as a piece of coarse canvas spread on a table, then breaking down the lump into crumbs or nodules under pressure by the flat of the hand using a gyratory type of motion, and continuing the same action on the nodules for a minute or so with regrouping under the hand as necessary. Under this treatment the nodules roll in changing direction while under compression in the same manner the single nodule behaves between the thumb and finger. A block having a suitable tractive surface may be substituted for the hand, and, of course, various mechanical means may be arranged to perform the required manipulation.

One of the fundamental requirements of the process is that the nodules traverse the contacting surfaces in rollwise fashion, that is to say, without slipping or smearing on the surfaces and without developing slip planes within the pulp itself. Another requirement is that the nodules are caused to roll in changing directions although this change in direction may take place either continuously, as caused by gyratory motion of the working surfaces, or intermittently as accomplished by short, repeated, straight line motion of the surfaces with regrouping and reorientation of the nodules between successive movements. A still further requirement is that the nodules be compressed while they roll.

These requirements impose certain definite limitations on conditions which may be employed in carrying out the process. The surfaces must possess the kind of roughness to provide good traction for the rolling nodules but without entanglement of fibers or otherwise impeding the rollwise traverse of the pulp over the surfaces. The relative movement of the surfaces must be slow, usually below 250 f.p.m. If a certain critical speed is exceeded, traction is lost and the pulp smears and builds up on the surfaces. Similarly, too heavy a compression will cause excessive flattening of the nodules and consequent breakdown of the necessary rollwise traverse. Operating pressures are usually under 15 p.s.i. of the surfaces contacting the pulp. Speed and pressure are interdependent in this regard, the lower the speed the higher the permissible pressure, and vice versa. The breakdown point between rolling and smearing is abrupt. It varies widely between different classes of pulp and between individual pulps of the same class. It is quite strongly affected by temperature, pH, and by certain additive ingredients. It has been found convenient to rate this property by what has been termed the curlation number which is the operating pressure in pounds per square inch at which a standard sample of pulp breaks down from rolling to smearing when gyrated between standard surfaces at a standard speed. The word standard here is used in the sense of a fixed condition arbitrarily chosen as suitable for the purpose. It is beyond the scope of this paper to go into the many relationships as brought out by this test, but it may be noted in passing that the new approach appears to open up an interesting field of study on certain characteristics of fiber surface and on how these correlate with factors of pulping, on the one hand, and with properties of finished paper, on the other.

Within the curlation limit, variation in degree of treatment can be obtained by control of the operating pressure on the pulp, the speed of movement of the contacting surfaces, and the duration of the action, in short, by the input of power. The power requirements of the process are unusually low. About 1 horsepower per daily ton, is sufficient for some applications, and the general range is from one half to several horsepower per daily ton. Consistency of the pulp has some effect on the result although obviously the local consistency of the nodules under direct action will depend more on the operating pressure than on any lower starting consistency. The usual range of consistency in carrying out the process is 15 to 25%. In preparing the high-consistency nodulated stock for the process, best efficiency is obtained by providing some agitation of the pulp during intermediate dewatering stages. This induces extreme flocculation and sets up the necessary cleavage zones to give easy formation of nodules in the dewatered pulp.

For an understanding of the process it is of interest to consider what happens to the individual fibers under the action as described. Figure 1 shows a conventionalized sketch of a single pulp nodule with its fibers intertwined in essentially random orientation. It will be apparent that when such a lattice structure is compressed, the individual fibers are subjected to numerous short-radius bends over and about one another; then, as the nodule is formed to roll under compression, these bending actions become very numerous and occur in continually changing directions, the more so if the direction of rolling is also changing. It thus requires only a short time, or put another way, a short path of rolling traverse before all the fibers have received intense short-radius flexing in many directions, and probably considerable twisting as well. Moreover, since cellulose and lignocellulose fibers are somewhat plastic, particularly when wet, the bends, kinks, and twists imparted by the flexing action take on a more or less permanent set depending on the severity of the treatment. A close analogy is, that when a moist sheet of paper or linen is well crumpled it will set in a strongly wrinkled condition which persists after drying, and a point to observe is that the change in configuration may be obtained without rupture or other physical breakdown of the sheet structure. So it is with pulp fibers.

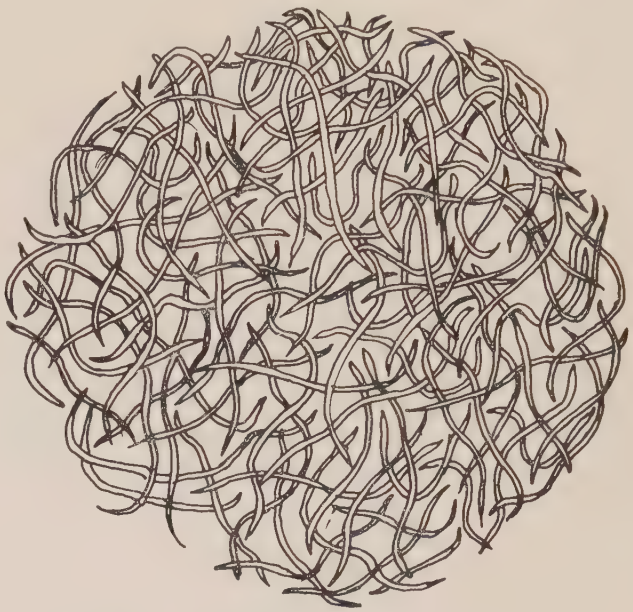

Fig. 1 Conventionalized pulp nodule

There is another important effect of the curlation method. The intense flexing action within the rolling nodule causes any fiber bundles to separate into single fibers, and thus the treated pulps are remarkably free of shives. In the same way the method is very efficient in defibering screenings and high-yield pulps. Again, a simple analogy may serve in explaining the effect. Consider several pieces of flexible cord glued together on their long axis. It will be found that the easiest way to separate the cords, and the one least likely to damage them, is vigorous, short radius flexing of the bonded unit throughout its length. So it is with bonded fibers.

In taking up the subject of the effect of the curlation process on pulp and paper properties, it is perhaps necessary to offer a few general explanations. In the first place, it is an entirely new field, apparently a broad and interesting one but with landmarks and boundaries by no means fully charted. Secondly, there is no single, easily defined curlation effect; there are many degrees and modifications of the treatment all of which may show up in different characteristic ways when applied

to the widely divergent types of pulp used in modern papermaking. Thirdly, there are the complex relationships of the curlation effect with those of other pulp processing steps such as beating, bleaching, and drying. Finally there is the limitation of present space and time in relation to the great volume of experimental data which has already accumulated. Under these circumstances the purposes of this paper will be best served by an attempt to indicate the highlights of the subject and to present a few selected examples which appear to typify the curlation effect in some of the directions thus far explored.

PULP PROPERTIES

As a first example of the process effect, Table I shows the change in pulp properties resulting from two increasing degrees of curlation, applied to slush, unbleached sulphite of newsprint grade.

The treatment is by hand, using a canvas covered block for rolling the pulp on a similar table surface. The indicated power input is estimated from correlation data with power-driven equipment developed later. The treated pulp nodules are reslushed directly after curlation by 2500 turns in the Standard British sheet machine disintegrator. Pulp tests here, and elsewhere in the present paper, are by the Canadian Standard method.

Table I. Typical Curlation Effects of Slush, Unbleached Sulphite

	Untreated	*Medium curlation, about 1 hp./daily ton*	*Heavy curlation, about 3 hp./daily ton*
Burst ratio	67	50	37
Tear ratio	140	164	198
Breaking length	7200	4800	3610
Per cent stretch	1.8	2.4	2.7
Bulk, cc. per gram	1.376	1.373	1.400
Stiffness, (Gurley) mg.	111	88	70
Porosity, sec.	19	12	9
Freeness, ml.	689	698	670
Drainage time, sec.	4.0	3.8	4.4
Wet burst ratio	0.790	0.760	0.675
Wet breaking length	205	146	110
Wet stretch, %	3.8	8.0	11.0
Per cent moisture-free after wet press	24.0	25.2	26.6

It will be noted that freeness tends to increase on curlation. A drop in burst and tensile is balanced by a sharp rise in tear. Stretch, both wet and dry, shows marked increase as does porosity (inverse of time reading shown). Stiffness tends to drop, and bulk, after an initial drop due to the elimination of shives, tends to rise.

Figure 2 is an attempt to illustrate the distinctive nature of the curlation effect by presenting the trend relationships between curlation and conventional pulp refining as typified by beating, again with reference to slush, unbleached sulphite. The broad bands are merely indicative of the range of values which may be obtained under normal variation of the two kinds of treatment and are not intended to define the limits of either. The curves represent the progressive change in the designated properties with increasing degrees of the two treatments, there being no direct basis, such as time or power of treatment, for comparison on a common scale.

It is apparent from the curves that the effects of curlation and beating present widely different characters; in fact, it is remarkable to what an extent the two effects are directly opposed. Both treatments, however, have shive reduction in common, although with curlation shives are eliminated very rapidly with low power consumption and without drop in freeness, whereas with beating shive reduction takes place gradually with high use of power and large drop in freeness. Small, birdseed type of shives often persist throughout beating, but they cannot escape being defibered during curlation.

There is another prominent curlation effect which does not show in the foregoing classification, and that is the change in sheet appearance. Apart from the improvement in cleanliness from elimination of shives and soft dirt, sheets of curlated pulp take on a matte look or put another way, the surface appears more optically level. There is a decrease in gloss and a corresponding

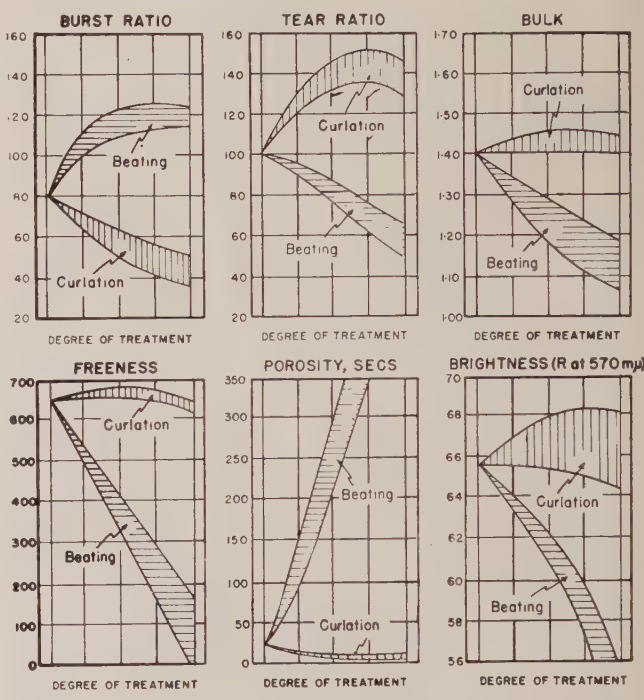

Fig. 2 Comparative trends on beating and curlation applied to slush sulphite pulp

increase in apparent brightness except for the view directly opposite incident illumination. This optical levelness of the surface seems still more pronounced in the case of colored sheets, and curlation appears to give a deeper shade of color with the same amount of dye. There is a slight tendency for opacity to increase with curlation. In regard to optical properties, therefore, the effect of curlation bears a general resemblance to that produced by a mineral loading material such as china clay, and again shows opposite trends from those of beaten pulp.

Still another typical change brought about by curlation is that the wet pulp will dewater somewhat further under a given pressure, and will also lose water vapor easier on drying. In terms of paper mill operation

these changes indicate a somewhat dryer sheet at the couch or wet press, and a lower steam pressure and less steam used for drying, presenting possibilities for economy and increased machine production.

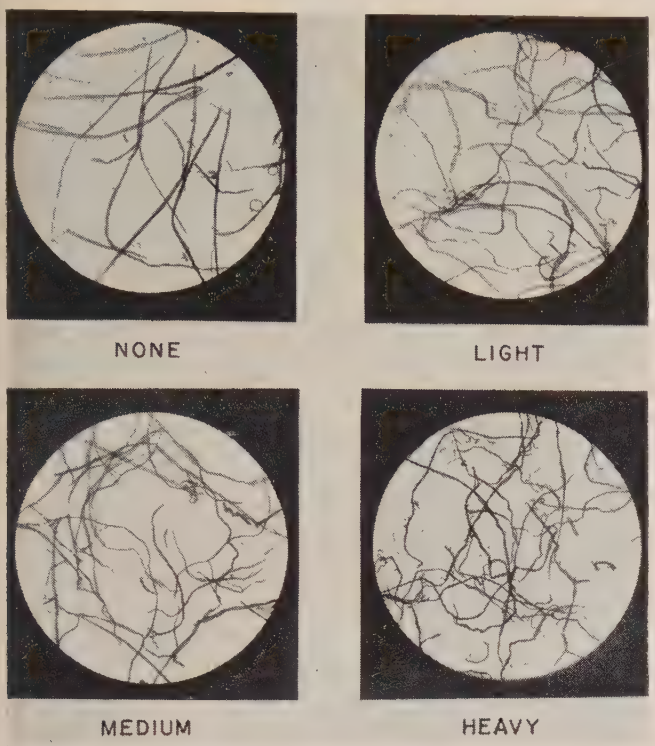

Fig. 3 Photomicrographs showing changes in fiber shape resulting from progressive degrees of curlation

The question of why curlated pulp exhibits these particular changes of quality opens up an interesting field of speculation. It would seem fairly obvious that an increase of bends, kinks, and twists in the fibers will result in less area of bonded contacts throughout the sheet structure, and that this would in turn account for lower burst and tensile and higher tear. Sharply higher stretch values could be attributed to cumulative coil effect from the greater degree of fiber contortion. The increase in porosity would seem to be only partly explained by the decreased area of bonded contacts, and this brings up another peculiarity. It has been found that curlation produces a change in cross-section shape of the fiber as well as that on the long axis. The usual somewhat ribbonlike flatness is changed toward a more tubular section. This reduces the projected width of the fibers, and in fact, curlated fibers do look finer. As a consequence, a lattice structure of such fibers in a sheet of paper of a given weight has more space between fibers transversely to allow freer passage of fluids, such as air in the porosity test, oil in the absorbency test, water in drainage and wet pressing, and steam in drying. Change in fiber shape could also account for the change in optical properties. The greater degree of fiber contortion causes more scattering of reflected light so that there is less visual definition of separate fibers. The result is the typical matte appearance of curlated pulp and its greater brightness in most views. Some of the optical levelness may also result from the fact that with curlated pulp there seems to be a marked absence of fibers exposed in full unbroken view at the plane of the surface, as compared with whole fibers which are readily visible in the case of untreated pulp, particularly after the fibers may have become glazed by heavy calendering.

Figure 3 shows photomicrographs which have been prepared to illustrate the change in fiber configuration produced by curlation, the pulp again being slush, unbleached, newsprint sulphite. The four photomicrographs represent untreated, light, medium, and heavy curlation. Apparent are the bends, kinks, and twists which the treatment has imparted to the fibers, and also the trend toward reduced projected fiber width.

EFFECT ON DRYING

Some of the relationships between curlation and drying of pulp are set forth in Table II, the pulp being unbleached newsprint sulphite, and the curlation treatment rather light. Column 1 represents untreated slush pulp; column 2, a sample of the same pulp tested after hot cylinder drying; column 3, another sample tested after curlation; and column 4, a sample tested after curlation and subsequent drying. Columns 5, 6, and 7 are a separate series to illustrate the effect of curlation following the drying step, that is, curlation applied to pulp reslushed after previous drying, the three columns representing the original slush pulp, the pulp after drying, and the dried pulp reslushed and curlated, in that order.

Table II. Relationships Between Curlation and Drying Unbleached Newsprint Sulphite

	1 Slush	*2* Dried	*3* Curlated	*4* Curlated and dried	*5* Slush	*6* Dried	*7* Dried and curlated
Burst ratio	77	38.2	55	28.3	87	66	57
Tear ratio	127	140	150	156	116	144	176
Breaking length	7480	4000	4940	2860	8100	6120	4610
Per cent stretch	1.86	1.68	2.61	1.68	1.65	1.17	1.70
Bulk, cc. per gram	1.372	1.569	1.374	1.601	1.399	1.496	1.438
Porosity (Gurley) sec.	21	9	12	5	...	...	...
Freeness, Can. Std., ml.	666	669	661	681	672	603	652
Drainage time, sec.	3.9	4.5	3.9	4.0	...	...	...
Wet burst ratio	0.828	0.796	0.795	0.728	...	...	...
Wet breaking length	217	192	149	141	...	...	...
Wet per cent stretch	3.5	4.2	7.9	6.8	...	...	...
Per cent moisture-free after std. pressing	22.4	28.4	23.4	30.2	...	...	...

Points both of similarity and of difference show up for curlation and drying. Strength properties and porosity exhibit quite similar trends for the two treatments, but stretch shows an opposing trend. Drying gives more bulking effect than curlation. In appearance, drying gives little of the typical matte effect produced by cur-

lation and, of course, drying accomplishes no deshiving or cleaning. When both curlation and drying are applied, the typical effects of each treatment appear to be additive, but in more pronounced degree when curlation precedes drying.

EFFECT OF BEATING CURLATED PULP

The question of the effect of beating on curlated pulp is a very complex one, for there are many kinds of beating and curlation, and many kinds of pulp. A specific example may serve to indicate the kind of result that is obtained. Figure 4, shows comparative beating effects on curlated and untreated samples of a slush newsprint sulphite. The curlation treatment is rather light, and the beating is done in standard manner in a Valley laboratory beater.

The curves show that the more divergent of the initial properties of the curlated pulp tend to approach those of the untreated pulp during the course of beating. Certain other characteristic curlation properties, however, persist strongly throughout beating, as witness, dry stretch and porosity. On the whole, it would appear that much of the curlation effect is retained, although in some respects it is masked by the very positive beating effect. Rate of freeness drop, however, appears little affected by the curlation pretreatment. With heavier curlation the effect is more persistent throughout beating than shown in the present example.

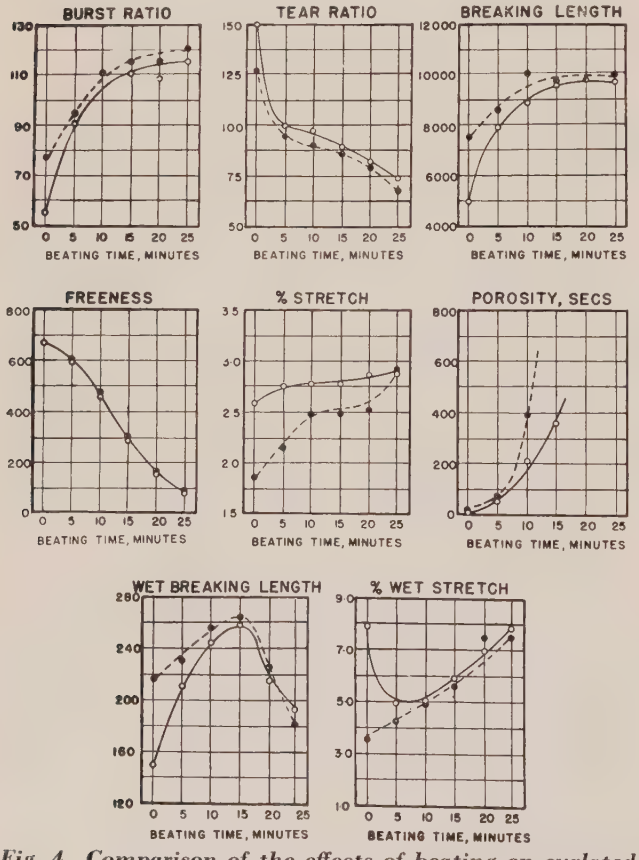

Fig. 4 Comparison of the effects of beating on curlated and on untreated slush sulphite pulp

○—— curlated, ● - - - - untreated.

In the different case of applying curlation after beating, very pronounced effects are obtained at all degrees of beating. Figure 5, shows the pulp quality comparisons on samples taken after increasing time of beating, part of each sample being tested, as-is, and another part after curlation. Again the pulp is unbleached, newsprint sulphite.

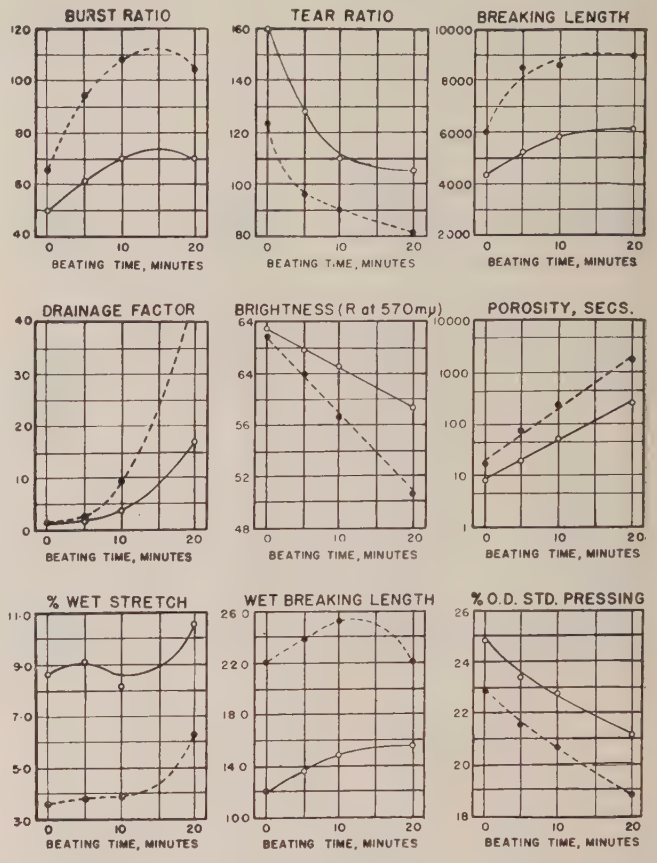

Fig. 5 Effects of curlation on slush sulphite pulp after various degrees of beating

○—— beaten and curlated; ● - - - - beaten only.

The curves show that curlation of beaten pulps produces the same trend of property changes that it gives at the unbeaten stage, but that in some respects the effect is accentuated. Noteworthy is the change in the drainage properties from curlation of the more heavily beaten samples. It is indeed surprising to find the sharply increased rate of drainage resulting from a simple, mechanical manipulation of the pulp.

Figure 6 illustrates a similar series run on an entirely different class of pulp, a high-grade, bleached sulphate, previously dried.

The results on the unbeaten sample are of interest since apparently the extreme properties of the untreated sulphate pulp influence the extent of the curlation effect. Thus, tearing strength is already near its possible maximum, and therefore, curlation cannot cause the sharp increase which in many cases is typical of the process. Similarly, bonding of the fibers is already so low that curlation cannot cause its usual decrease of burst and tensile strength. The increase in stretch, however, shows that the effect of curlation on fiber configuration is still present, and this may be verified under the microscope. As beating of this pulp progresses, curlation again asserts its typical effect on all properties including

a sharp increase in the rate of drainage imparted to heavily beaten pulp.

Soda pulp furnishes another example of extreme initial properties influencing the results obtained by curlation. Here the very low initial burst tends to increase, and bulk to decrease slightly. Stretch and tear, however, show typical curlation increase, and the usual improvement in optical levelness is also in evidence.

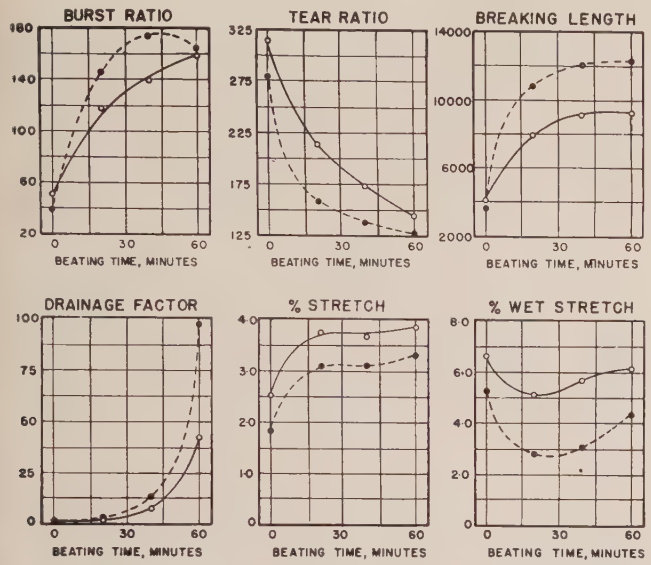

Fig. 6 Effects of curlation on dried bleached kraft pulp after various degrees of beating

○—— beaten and curlated; ● - - - - beaten only.

As might be expected groundwood is more resistant to influence by curlation than are the chemical pulps. The application of 1 to 2 hp. per daily ton, as in most of the foregoing examples, produces little apparent effect on groundwood. If the power is stepped up to say, 5 to 10 hp. per daily ton, however, groundwood shows a readily perceptible change. Table III, columns 1 and 2, gives the result obtained by curlation of newsprint groundwood using about 8 hp. per daily ton applied on hand treatment is not the equivalent of that obtained by a higher intensity of treatment. The table shows the typical curlation effect on all properties except tear and freeness, both of which are somewhat reduced. It seems strange to find increased porosity with decreased freeness. The curlated groundwood has the expected more even texture and appearance, and the change in this direction appears greater than that which might be obtained by the same extra power added at the grinder. In another test, using a coarser, weaker groundwood, curlation with 5 hp. per daily ton, gave a 50% increase in burst, a slight rise in tear, and again a more even texture.

Table III also shows the effect of the curlation technique applied to groundwood screenings, using a power input of about 40 hp. per daily ton which for curlation must be considered very extreme. There is, in fact, little present indication how the process might be applied in this high-power range commercially, but the experimental results are included here as a matter of some fundamental interest. As far as is known, this is the first demonstration of a very superior groundwood pulp obtained from groundwood screenings. Considered at equal freeness it is perhaps the highest quality of groundwood yet obtained by any means. The exceptional test values may be judged by comparison with those of the newsprint groundwood of column 2. In texture and appearance also, the special sheet compared favorably with regular newsprint groundwood.

Screenings from the usual types of chemical pulps are well defibered by curlation with moderate application of power, and with high freeness maintained in the resulting pulps. Broke and waste paper also yield readily to the action, and clear pulps are obtained from even the most resistant papers without the use of chemicals or boiling out treatment.

PULP PROPERTIES AFTER EXTREME PROCESSING

During the course of the development the natural question arose as to what happens to the properties of a pulp when it receives an extreme degree of curlation. Clearly, pulp fibers cannot withstand the intense flexing action of the process indefinitely without some form of breakdown. Table III includes a comparison showing the effect on an unbleached sulphite of an extreme curlation treatment, applying about 50 hp. per daily ton by a power driven, gyrating plate. Again, the results are presented for their fundamental rather than imme-

Table III. Miscellaneous Curlation Applications

	Newsprint groundwood		*Groundwood screenings*		*Unbleached sulphite*	
	1 Untreated	*2 Curlated 8 hp/daily ton*	*3 Untreated*	*4 Curlated 40 hp/daily ton*	*5 Untreated*	*6 Curlated, extreme 50 hp/daily ton*
Burst ratio	21.2	19.1	12.3	38.5	89.3	60.0
Tear ratio	62	55	43	85	130	146
Breaking length	2230	2060	1255	3530	7560	4100
Per cent stretch	1.44	1.51	0.81	1.96	1.71	3.60
Bulk, cc. per gram	2.322	2.277	3.418	2.000	1.361	1.299
Porosity, (Gurley) sec.	22	19	0.5	48	15	51
Stiffness, (Gurley) mg.	91	83	122	87	121	51
Brightness, R ∞ (570 mμ)	...	...	...	...	62.1	62.2
Printing opacity	...	...	...	...	87.4	90.6
Freeness	94	51	641	108	691	72
Drainage time, sec.	15.6	16.1	4	18.3	4.5	24
Wet strength ratio	0.279	0.177	0.184	0.277	0.840	0.640
Wet breaking length	48	27	47	59	235	115
Wet stretch, %	9.1	12.3	3.7	5.5	3.0	8.3

diate practical interest. The treated pulp, column 6, exhibits some noteworthy new trends. The great drop in freeness shows that the fibers have finally undergone rather drastic disintegration. Yet at the low freeness, tear has gone up to a high value, and burst and stiffness have fallen. Sheet porosity is still very high for such a large drop in freeness. Perhaps most remarkable of all, printing opacity has risen and brightness is unimpaired. The change in appearance is equally striking. The rather sleazy look of the initial unbleached sulphite sheet has changed to the level, somewhat chalky appearance of heavily loaded book paper. Altogether the treated pulp presents a unique combination of properties, one which seems to offer much food for thought in the field of pulp and paper technology.

There is quite a different kind of extreme curlation effect obtained in quite a different way. It is found that increasing the holding time between curlation and the subsequent reslushing of the curlated nodules gives a more pronounced degree of the typical process effect. Holding the nodules 1 hour produces a noticeable increase, and longer periods strengthen the effect still further. This kind of change is accentuated by holding the curlated nodules under pressure, or by heating them, or in still greater degree by partial or complete drying of the nodules. The obvious explanation would seem to apply for all these after-treatments, namely, that in the curlated nodule the tightly intertwined fibers are still held under light deformation forces, and these forces continue to exert their influence for some time. Pressing, heating, and drying increase these forces or render the fibers more susceptible to them. The net result is an increased set of the bends, kinks, and twists of the fibers. This explanation is supported by the fact that with tighter, higher-consistency nodules the effect of the after-treatments is accentuated. By selecting certain combinations of after-treatments, extreme changes in pulp properties have been obtained. Sheets of great softness have been prepared from hard newsprint sulphite. Burst has been reduced to near the vanishing point. Tear values of newsprint grade sulphite have been raised as high as 275. It may be added, however, that in progressing toward greater softness by decreased fiber bonding, tear rises to a maximum and then declines, so that with sheets of extreme low burst, tear may have passed the peak and reverted to near its initial value. Thus a final combination of a 10 burst ratio and a 120 tear ratio is possible for treated newsprint sulphite. Clearly, extreme curlation effects of this nature are not accompanied by any disintegration of fiber structure as occurs with the other class of extreme effects produced by extra-high input of curlation energy.

EFFECT OF TEMPERATURE

Referring again to the process itself, there are several additional points which may be of interest in rounding out the present preliminary account. Temperature has quite an effect, both on the curlation operation and on the resulting changes in pulp properties. Higher temperature increases the ability of a pulp to absorb curlation power without smearing and consequent checking of the action, and this has considerable practical significance in the problem of obtaining high capacity from commercial equipment. At the high consistency of curlation, possible raising of temperature is only a minor economic factor. The effect of temperature on the property changes from curlation varies somewhat with the nature of the pulp, but in general a higher temperature works toward a softer curlated pulp, that is, one with lower burst and stiffness, and higher tear, bulk, and freeness. Thus temperature tends to accentuate the typical curlation effect.

PULP CONSISTENCY

Pulp consistency similarly has an influence on the effect of the process, although as noted earlier its influence in the lower consistency range may be tied in with curlation pressure. Furthermore, in practical application, consistency may not ordinarily be an independent variable. Taken by itself, however, higher consistency like higher temperature seems to work in the direction of an accentuated curlation effect which is toward a heavier set of the altered shape of the fibers and all that this implies in terms of pulp and paper properties. On the other hand, the somewhat separate deshiving effect of curlation seems to be more pronounced at the lower consistency, for example, under 15%.

COMMERCIAL ASPECTS

As noted in the foregoing account, the stretch properties of pulp, both wet and dry, are increased by curlation. Wet stretch is particularly sensitive to the treatment, and gains of 300% are readily obtained on slush unbleached sulphite. Accordingly, wet stretch has proven a very useful guide throughout the course of the development work on the process, and it should continue to serve as a convenient aid in defining curlation degree. The test has also supplied added insight to some of the more fundamental relationships of pulp and paper quality. The test used is that developed at the Pulp and Paper Research Institute of Canada by W. S. Morris and H. de Montigny. (*Pulp Paper Mag. Canada*, 42: 410 (June 1941)).

It is not the purpose of this paper to deal with the commercial aspects of the curlation process, but a few general observations may be of interest. From the broad viewpoint, perhaps the most significant fact is that the process materially extends the existing range of pulp properties and combinations of properties. It appears to break down some of the hitherto limiting boundaries in the field. A given pulp can be changed further and in more directions than formerly, and a given raw material can serve for a wider range of pulp requirements. Considering the variety of specific requirements in the whole field of pulp conversions, this increase in flexibility should prove useful. The benefit might show up in the adaptability of raw material; it might appear in operating characteristics; and it might be a factor in quality of product. It might contribute to new applications, and even to new products.

The tendency of the process to give a softer pulp is of interest in such conversions as tissues, book papers, and folding boxboard. The change in appearance and optical properties is of interest in nearly all conversions. The increase in stretch is an important strength factor in many uses, such as the running of a paper web in printing and other conversions, or the resistance of

paper bags and cartons to rupture by impact. High wet stretch is of interest in wet molding and embossing. The increased porosity may have some interest in coating and impregnating operations. The extra kink of the fiber may have interest for felted pulp products. The somewhat greater stability of sheet surfaces and structure is of interest where scuffing, fuzzing, and sheet curling are factors. The deshiving influence of the process is of interest generally.

On the economic side, the most obvious and direct interest lies in the possibilities for higher pulp yield. There is a significant fact here. The tendency of higher yield pulps to be harder is opposed by the tendency of the present process toward a softer pulp, and consequently, when the process is applied at increasing yields, the net change in pulp properties is relatively narrow. There is, moreover, the great gain from the powerful deshiving effect of the process. There would seem to be few conversions which would not allow at least some increase in pulp yield in this manner, but it will take trial and time to arrive at the practical limit in any specific application. The same applies to the more indirect economies which seem to be indicated for the process, such as those in raw material, furnish and machine operation.

This leads to the reason why the words "new approach" appear in the title of this paper. It is not only that the work appears to follow a new direction of attack on the problem, but also because in the broader aspects many of the indicated objectives have in fact only been approached. The present account charts the course of the approach, and tells what has appeared to view from the new position. The view presents points of interest, but it also shows up the distance yet to be covered. It is hoped that the present account may stimulate further progress.

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APPENDIX

Ed. Note: Because of probable interest in the construction of the Curlator, the following description of the unit taken from "The Curlator-Its Application to High Yield Newsprint Sulphite" by Frank P. Silver, Price Bros. & Co. Ltd., Riverbend, Que., has been appended (*Pulp Paper Mag. Canada* 50, No. 3:195–200 (Convention Issue 1949)). This paper was presented at the 1949 Annual Meeting of the Technical Association but will not be published in *Tappi*.

This report was of special interest as an account of preliminary investigational work with the radically new type of pulp-processing equipment known as the Curlator. The unit used in this preliminary work was more than an experimental unit; it is, in fact, the initial commercial scale model representing the difficult jump from small laboratory apparatus. It was designed and built for use in working out the proper characteristics of a perfected commercial machine to follow, and for studying some of the commercial applications of the new kind of treatment performed by the machine, including, but by no means limited to, the application on high-yield sulphite. Similarly, the present setup of the machine in the mill system was experimental in nature to explore certain possibilities for increasing the yield of sulphite for newsprint, and at the same time to prove out the machine in prolonged operation under mill conditions.

Figure 1 is a side elevation of the commercial Curlator showing features of interest in operation. The stock,

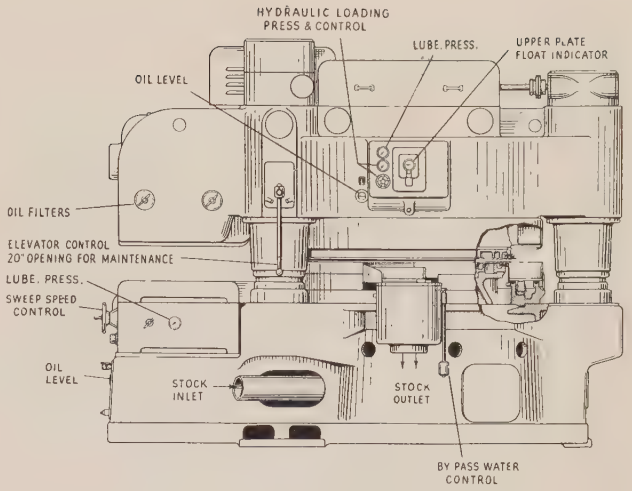

Fig. 1

supplied from a headbox, enters the center of the machine, progresses radially outward during treatment, is picked up by a rotating turntable at the periphery of the working zone, and doctored off at the stock outlet.

Figure 1A is a cross section and Fig. 1B is a partial plan of the working zone. The stock at 3 to 4% consistency enters at A through the bore of the rotating sweep and spreads out at B where it begins to thicken.

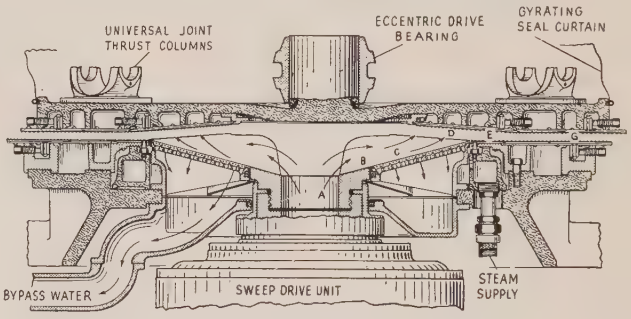

Fig. 1A

At C the thickened stock gathered on the perforated plate is urged outward and upward by the slowly advancing sweep arms and is subjected to motion impulses from the gyrating upper plate tending to form it into balls. At D the stock is forced into a wedgelike space over the top of the sweep arms where it is repeatedly

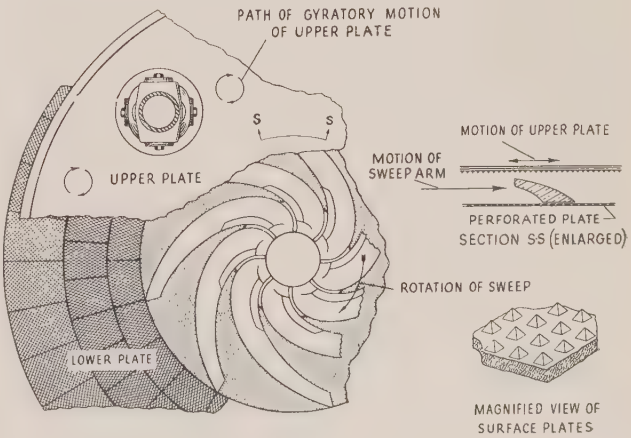

Fig. 1B

compressed and released by the tractive surface of the gyrating upper plate, all points of which travel in circles in the order of $2^1/_2$ inches diameter. This action continues the formation of nodules and compresses them to a consistency of around 20% while the released water finds its way downward through the perforated plate. At E the thickened nodules begin their rolling traverse between the tractive surfaces of the upper and lower plates. The slight angle of the upper plate provides a clearance pulsation which aids in advancing the nodules radially outward at this point. In the balance of the working zone G, the nodules are rolled in all directions under compression between the upper and lower plates. Their path of motion is generally circular with gradual progression toward the periphery of the plates where they are discharged onto the turntable. The bypassed water rejoins the nodules at the stock outlet.

The upper plate is free to float vertically and the degree of compression applied to the rolling nodules is controlled by oil hydraulic pressure (loading pressure) communicated to the upper plate by the thrust columns. The thrust columns also serve to hold the upper plate parallel to the lower plate and to prevent its rotation about the central axis. This is a relatively slow speed and low power operation. Surface speed of the upper plate is in general below 300 f.p.m. and the sweep speed is generally below 20 r.p.m. Power consumption may range up to 75 hp. for a machine having a plate 53 inches diameter and capacity to process up to 40 air-dry tons per day. Although the pressure on the nodules may be in the order of 1800 pounds per square foot of plate area, there is little or no water pressure in the working zone G. The nodules alone support the load.

The degree of treatment administered to the pulp as well as the power consumed by the machine is controlled by the loading pressure with essentially no effect on the throughput. The throughput is controlled by adjustable gates in the headbox, or by pressure control on the bypass water, or by the speed of the sweep with essentially no effect on the power consumption. The clearance between the working plates may vary up to $^1/_2$ inch and, since clearance is a handy guide to throughput and working conditions, a "float" indicator is provided. Variation of supply consistency does not affect throughput or degree of treatment but only affects the quantity of the bypassed water. In case steam is used to raise the temperature of the nodules it is added through a ring of nozzles outside the dewatering zone.

Application of Statistical Methods to Paper Testing

J. H. TOULOUSE

This paper is an introduction to the application of statistical methods to paper testing. The laws of probability, the two general methods of comparison, frequency distribution, sampling, and the use of control charts are considered briefly.

THE subject of this paper has to do with the application of the laws of probability to sampling and testing. It might equally be called the law of chance because using the narrow field of probability—"statistics" actually means the application of the laws of gambling to the art of taking samples for testing. It will be seen that since the items that might be tested are in themselves variable, the selection of any one of them as a sample for test purposes actually becomes a gamble. Since this means that there is a certain amount of actual risk involved, there should be agreement that in order to do a better job of testing from samples more should be known about the laws of gambling (or probability) as it affects the selection of samples.

Statistical probability is thought of as being quite new in paper testing. It was quite new in the industry concerned with glass containers, and yet it is not a particularly new thing, although in paper and in glass it is being applied to two of the oldest arts, long after applications to other fields.

The first development of the laws of probability came from the work of a young French mathematician who was retained by a syndicate of gamblers in Paris to determine for them something more concrete about the law of chance. For some little time this was the only application. Many years later, Mendel applied it to his study of variations in the pea plant and his one publication of this has become the starting point of many of the studies of heredity both in the plant and animal kingdom. Later the agricultural people took it up and some of the greatest advancements have come from the field of agriculture. The bacteriologists began to use it a few years ago, together with other sciences, but it was not until more recent years that the full application was started in industry. Thus it would appear, manufacturing industries have been well behind other sciences and arts in the development of this real tool to quality control.

One branch of sampling, the political "poll," recently took a beating, but work with inanimate objects is much more certain. These failures point all the more to the necessity of securing a "representative" sample.

Until the fact is realized that all manner of things are quite variable, there is the tendency to feel that everything ought to be made exactly alike. If the yardstick of comparisons is on a large scale, it might be assumed that they are exactly alike because the method of comparison will not measure close differences. If a scale of hundreths of an inch or a micrometer is used instead of a yardstick, then differences begin to be apparent and this is the backbone of the application to sampling. It might be considered a good working rule that the measurement scale, if measurements are being used, should be several times as close and as accurate as the variation which it is desired to measure.

COMPARISON METHODS

This introduces immediately a discussion of the two principal branches of testing or comparison. Both are

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employed in quality control, in testing, and in sampling. One of these is called the "method of attributes" and is exemplified by the go-no-go gages frequently used. In this type of evaluation, a piece is either within the limits of the gage or is outside, either on a low side or a high side. Such methods are usually very simple as they require no particular manipulation on the part of the tester and use a gage which is made quite accurately to one or two limits of measurement. It has the advantage that it can be used by an inexperienced tester who needs only to be taught the manipulation of the gage which he is using. It has one drawback, in that, a large sample is required, offset by the advantage that the measurement of the individuals in such large samples is rather quickly performed. It has the great disadvantage of giving little warning that a process is about to produce material out of specification, until off specifications ware is actually being produced. Refinements of the method do allow types of warning systems to be developed, principally by examining for slightly narrower working limits, inside the tolerances. The method is therefore unworkable so far as control is concerned unless a few items are being produced outside the scale. The reporting of the examination is on a basis of percentage of such items that are outside the scale of the measuring device. Specifications are written: "not more than 10% outside of stated limits," etc.

The second general type of measurements is called the method of variables. In this case much smaller samples can be examined but the operation is more tedious because an exact measurement, within the limitations of the measuring device, is sought for each dimension or piece that is examined. It requires higher skill on the part of the operator and is more time consuming. It has the advantage of requiring a smaller sample and making possible more exact calculations. It is very desirable in order to reduce costs if the test destroys the sample.

FREQUENCY DISTRIBUTION

Before one can start a program of such applications it is necessary to have more than a casual idea about the variations of the material which is to be tested. This usually calls for some study on the basis of exact measurements even though go-no-go gages are finally to be used in routine sampling. Examples of some of this work can be shown in the form of what are known as "frequency distributions" or "histograms." In making up such a graphical distribution, a scale of measurement is chosen which goes from the smallest to the largest individual and this scale is broken up into a number of small subsections or cells. There are definite rules for the choice of the number of cells which need not be discussed here but usually 100 measurements will be broken down in seven or eight such subgroups. On the graph are plotted the number of times a measurement falls within the limits of the subgroup. Because the usual distribution is one where the center of the scale has a large number of individuals, and the two ends a smaller number, the curve connecting the points of the graph assumes a sort-of bell shape which in its perfect form is known as a "normal" frequency distribution.

Measurements of a large number of divergent things usually give such patterns and, therefore, there can be assurance that if such a pattern is developed, there is an approximately "normal" system, or family, of items Since rather exact mathematical calculations can be made based upon the perfectly "normal" distribution, then these applications apply quite generally to the measurement that might be made on paper. Since variation is found in all things—tests upon paper and paper products, because they are found to vary, are no different than other fields of manufacture or substance.

Inspection of these frequency distributions immediately make clear one important respect which makes the statistical determination differ from ordinary calculations. It is quite common to make a number of measurements, add them together, and divide by the number of determinations in order to obtain an average. This is where most studies stop. In applying statistics however, there is one step further. Another type of calculation is used which measures the spread of values from largest to smallest and the degrees to which they tend to fall around a middle zone or average. This measurement of spread is called the "standard deviation," quite often used as an abbreviation by means of the Greek letter sigma (σ). Given these two calculated measurements called the standard deviation and the average, a great deal more is known about the material than by the average alone. It is the direct key to tolerances.

Just as one example it might readily be shown that if two productions or lots of paper had the same average strength, but one had a very narrow spread of values and the other a very large spread, then the one with the large spread might not be fit for use because of a few areas on the paperboard that would have too little strength for the need. A common term in the industry, "wild" paper, is a practical expression of such a condition. Statistical methods can now be applied to determine how wild a paper is and a fine distinction approached of where a paper becomes usable and where it is no longer usable for some specific purpose involving the characteristic measure.

SAMPLING

There is not time in one brief discussion to enter into the many ramifications of this use of probability. One very important field which cannot be discussed fully is that of choosing the proper number of samples to examine. Clearly if the items to be tested differ somewhat, then a small sample cannot be expected to have representations of both the minimum and the maximum spread as well as the center. Many studies have been conducted using far more tests than would ever be considered necessary, in order to find out how few tests may be employed to tell accurately enough for the purposes what is needed to be known from the test results. This study is a field in itself and it is already pointed out that too small a sample is used in many tests to do any real good.

An example can be cited from observations made some years ago on the visual examination of glass received in carload lots by a customer where the same principals apply as would apply to paper testing. In this instance four people examined separate samples from the same car of bottles for a minor fault. Each took a sample of 300 bottles to examine. One found

Table I. 5% Blue Beads (Below 200 p.s.i.)

Number of blue beads in six	Number of samples in each group	Per cent in each group	Theory % in each group	Number of blue beads in retest of 24 (passing) 0	1	2	3	4
0	34	68	73.51	..	..	..	..	..
1	14	28	23.21	..	..	..	..	..
2	2	4	3.06	..	1	1	..	..
3	...	...	00.21	..	..	..	..	..
4	...	...	00.01	..	..	..	..	..

Total 50
Average 6%

Retest made on all lots giving two or more blue beads in first sample of six.

4.0% defective, another 6.3%, a third 4.6%, and the fourth 2.3%. Thus, one found nearly triple the number found by another "sampler." A great deal of kidding followed, running from "better get some new glasses," to "must be seeing double today," yet these four people were in rather good agreement statistically. The average of their results was 4.3%. It would have been reasonable under these conditions (and it can be proved mathematically) to expect values ranging from 0.9% to 7.8%. Just how, and why, will be shown later.

If each sampler had looked at only 100 bottles, and if the same average, 4.3%, had been found for the results of all four combined, mathematical calculations show that their individual values might range from 0.0% to 10.4%. If each had looked at 1000 bottles, the range would have narrowed to between 2.4% and 6.2%. Examining still larger numbers would have increasingly narrowed the range. Choice of the size of the sample would be governed by the degree of certainty desired and its cost.

In the preceding paragraphs it has been indicated that there was a mathematical basis for the sampling numbers chosen. Some illustration should be given of the methods by which the general limits of variation can be estimated.

Normal Curve of Probability

One of these is based on what is called the "normal curve of probability," which has already been referred to as a "pattern," and expresses the range within which nearly all the values (99.73% of them if the distribution of values is "normal") can be expected to fall, as a function of the average of such values. It is expressed by the formula:

$$\bar{P} \pm 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

where

$\bar{P}$ = average fraction defective of values from a number of groups
n = number of samples in each separate group

In the problem illustrated earlier, where $\bar{P}$ was 0.043 (4.3% is 0.043 when expressed as a fraction), and with n at 300, or 100, or 1000, the several kinds of limits used are:

When $\bar{P} = 0.043$
If $n = 300$, upper limit is 0.078, lower limit 0.008
If $n = 100$, upper limit is 0.104, lower limit 0.000
If $n = 1000$, upper limit is 0.062, lower limit 0.024

These limits are easily calculated. It will be seen very readily that only by examining more and more samples at a time can a point be approached where there is little variation in successive sampling results; conversely, by taking fewer and fewer samples, greater and greater variation will result. Since n is in the denominator of the fraction under the square root sign, it is necessary to quadruple the sample size in order to double the accuracy.

Some of these statistical sampling methods can be tried out in advance by means of mixtures of beads of differing color, and drawing small portions of beads at a time to represent a sample. For example, take three groups of beads in which one has 5% blue beads to represent 5% of bursting strength tests falling below a prescribed 200 p.s.i. test, another with 15% red beads representing 15% below 200 p.s.i. or border line for trade acceptance, and the third with 25% green beads to represent a product under the acceptable limit.

The normal method is first to make six tests. If no more than one test falls below 200 p.s.i. the sample is passed. If more than two fail, a retest of 24 is taken on which no more than four can fail.

Setting up a box with 5% blue beads gave the following results:

Theory frequencies are found expanding the binomial $(0.95 + 0.05)^6$ where the first term gives the fraction of times zero blue beads are found in a sample of six, the second term the fraction of "one's," the third term the fraction of "two's," etc.

Note that in Table I, there were sampling results ranging from none to two tests in six below 200 p.s.i. The two times that two tests were encountered, the retest passed the lot. The actual beads found averaged 6%, whereas the sample is known to average 5%. Actual frequency for each level agreed well with the theory frequency.

Table II. 15% Red Beads (Below 200 p.s.i.)

Number of red beads in six	Number of samples in each group	Per cent in each group	Theory % in each group	Number of red beads in retest of 24 (passing) 0	1	2	3	4	(rejected) 5	6
0	17	34	37.73	..	..	..	..	..	..	..
1	19	38	39.93	..	..	..	..	..	..	..
2	13	26	17.62	..	2	2	4	3	1	1
3	1	2	4.14	..	..	..	..	1	..	..
4	...	...	0.55	..	..	..	..	..	..	
5	...	...	0.04	..	..	..	..	..	..	
6	...	...	0.00	..	..	..	..	..	..	..

Total 50
Average 16%

Retest made on all lots giving two or more red beads in first sample of six.

Table III. 25% Green Beads (Below 200 p.s.i.)

Number of green beads in six	Number of samples in each group	Per cent each group	Theory % group in each	Number of green beads in retest of 24 (passing) 0	1	2	3	4	(rejected) 5	6	7	8	9
0	6	12	17.80	..	..	..	..	..	..	..	..	..	..
1	18	36	35.60	..	..	..	..	..	..	..	..	..	..
2	14	28	29.66	..	1	..	1	1	1	3	3	2	2
3	10	20	13.18	..	..	1	1	1	2	1	2	1	1
4	2	4	3.30	..	..	..	1	..	1	..	..	..	..
5	...	...	0.44	..	..	..	..	..	..	..	..	..	..
6	...	...	0.02	..	..	..	..	..	..	..	..	..	..
Total	50			Retest made on all lots giving two or more green beads in first sample of six.									
Average	28%												

Samplings for 15% red beads were made as follows: Theory is obtained by expanding the binomial $(0.85 + 0.15)$.[6] Results are shown in Table II.

The samplings for 25% green beads were made as follows:

Theory frequency was obtained by expanding the binomial $(0.75 + 0.25)$.[6] Results are shown in Table III.

CONTROL CHARTS

The data just used can illustrate two of the frequent uses of sampling: one is to control a process during the time of manufacture, while a second is to serve as a basis of agreement between buyer and seller on sampling. In manufacture, use is often made of what is called a "control chart" which is a series of periodic small samplings. In the case of the illustration just used, each drawing of beads might be considered a point for a control chart. The upper and lower limits, beyond which it is improbable to go unless the process itself is changing, are calculated from the data as shown. For instance if a number of samplings had been made without changing the proportion of beads and then a quantity of the red beads suddenly dumped in there would be a distinct change in the process which would show up on the control chart. The formula previously given is used to establish these limits.

This might be illustrated a little easier by a throw of dice. Here, a set of twelve dice substantially alike, which might be considered samples from a process is used, and the number of "six spots" in each roll of the twelve dice will be counted.

Now everyone knows that each dice has six sides, and only one "six spot." On each roll of twelve dice, therefore, there should be two sixes "on the average." Nearly everybody knows a little about the perversity of dice! But now it is possible to have the perversity under a little control.

It has just been shown that for a practical illustration, 99.73% of all experimental values should fall in the limits of plus or minus three standard deviations from the average. It can be shown that for practical purposes $\sqrt{(\bar{P}1 - \bar{P})/n}$ is equal to one standard deviation where $\bar{P}$ is the average per cent defective. In this case $\bar{P} = 0.1667$ (2 out of 12) and $n = 12$. Solving this, it is found that one standard deviation equals 0.1076. Three times this value is 0.3228, which, added to the original fraction 0.1667, gives 0.4895 as the maximum fraction of the twelve dice that could come up as "sixes" 99.73% of the time. Twelve times 0.4895 is 5.87. In other words, six or more "sixes" in a single roll of twelve dice would be so rare as to come up less than three times in a thousand throws. (To roll six or more "sixes" twice in a row might become a calamity.)

A control chart can be made by drawing thirteen parallel horizontal lines, numbered 0 to 12 from the bottom up. Vertical lines could be drawn, one for each throw of the dice. The line numbered "2" could be made heavy to indicate the theoretical average. A heavy dotted line could be drawn just below line number "6," at a value of approximately 5.87. This is the upper "control line," found by the formula in P already used in the bead box test. When the number of "sixes" in a single throw is plotted on the corresponding numbered line, the process is considered in control, if no points fall above the upper control line at 5.87. The use of a control chart can be illustrated by making a number of successive rolls of dice and plotting them on the chart.

In order to illustrate a process that has changed, twelve dice loaded to come up "sixes" will be substituted after several throws and it will be seen how quickly there is more than five "sixes" in a single throw.

The rolls with the normal dice were as follows: 0, 3, 3, 2, 3, 1, 1, 2, 2, 1, 4, 2, 2, 1, 4, 2, 1, 3, 0, 3, 5, 1, 1, 4, 1, which are an average of 2.12 "sixes" per throw. No value exceeded the upper control limit at 5.87. The value 2.12 is quite close to the theoretical 2.00.

The rolls with loaded dice were as follows: 9, 7, 6, 10, 8, 6, 10, 8, 10, 9, 11, 11, 10, 11, 11, 7, 12, 7, 11, 8, 10, 11, 7, 8, 11. They averaged 9.16 per roll, or well over four times the normal average and all were over the theoretical 2.00. The probability of 25 values in a row falling above the theoretical average in a population "in control" is very remote.

As control charts go, this illustration may be somewhat crude, but it does show how the "change in process" (substitution of dice) was detected almost at once by the use of control limits. When applied to a production process, the method becomes a powerful tool for quality control purposes.

Now it doesn't matter what measurement is being used or what is being studied so far as the application of the control chart is concerned. Control charts can be made on measurement details as well as attribute details, with the measurement type of control chart being more accurate and giving more information for the control of a process.

In an agreement between a purchaser and seller, control chart principals can be used, but in general, since a shipment loses its identity in point of time of manufacture, other means of sampling are used. To be fair for either side they must include a reasonable allowance for the fact that quite often a good lot of goods might give a bad sample and a bad lot of goods might give a good sample. There are several such methods, but the most popular is that used by the Army Ordnance Department and based on tables which are called the Army Ordnance Tables. Other branches of

service have used similar tables, or a later type called the sequential sampling method, which is even more definitive. This might become "suggested reading" if it is desired to make further study.

The author would like to point out some of the variations found in his earlier studies of paper testing. One of these was on a kraft liner board to which the bursting strength test was applied. One hundred tests made on the same board ranged from 86 to 125 p.s.i. Statistically, one value was found between 86 and 90, eleven between 91 to 95, fifteen between 96 and 100, twenty between 101 to 105, twenty-eight between 106 and 110, sixteen between 111 and 115, eight between 116 and 120, and one between 121 to 125. The average of all these measurements was slightly over 105 p.s.i. It is readily seen that this average does not tell much about the spread. The standard deviation was calculated at 7.54 p.s.i. and it is generally accepted that about 99% or more of the measurements should be within three times this value on either side of the average. This gives a logical spread from 82 to 127 p.s.i. which actually includes all the values tested so that it can be assumed that this is a perfectly normal product and that the results were perfectly normal, provided control charts show no great change in the process from time to time.

A similar study of caliper shows a range from 12.3 to 14.3 thousandths and a standard deviation of 0.00022 which again shows that the measurements were normal. A study of weight showed a similar spread and again a normal distribution of values.

One of the most extensive studies to date has been that of the variation of bursting strength tests on two kraft papers. One hundred such tests ranged from 74 p.s.i. minimum to 117 p.s.i. maximum on one liner, and 89 p.s.i. minimum to 124 p.s.i. maximum on another liner. The question was as to whether these liners represented the same stock or could reasonably be considered from the same run. Grouping the 100 tests of each liner in successive subgroups of the three (the 1st, 2nd, and 3rd, then the 2nd, 3rd, and 4th, etc.), where one board averaged 105.69 and the other 95.68 for the 180 measurements, shows that in 87 times out of 100 it would be possible to distinguish the stronger liner from the weaker, but in 10 times, the reverse was true. In other words, it would be possible to be wrong 10% of the time. Putting them together in averages of six found the correct designation 91% of the time, and only when the average of twelve tests was used was it possible to be able always to distinguish the high from the low on the basis of test data. From this it would be concluded that it is impossible to state with certainty that two series of tests are different when the actual or true average is only 10 p.s.i. apart unless one takes the sample of twelve which is more than is commonly used for any routine experiments. A sample of six tests could not tell the real difference between two liners 17 pounds apart, and the average of three test values could not tell the difference between boards with a 100% certainty when they are as much as 23 pounds apart in strength.

In order to get greater definition one has to go beyond twelve tests. The grouping of all these values in groups of 24 narrowed the spread of certainty down to 5 pounds, and going to tests of 48 the uncertainty dropped to 3 pounds. Thus, for any research work it would be necessary to take what would now be considered an unreasonable number of tests in this particular interest. It can be stated, in general, that in order to double the accuracy of test results it is necessary to take four times as many samples and this general rule has a very good mathematical background.

While this has been a long discussion, it is actually only the beginning of a statistical approach. The method is not difficult but it takes some time to master. Most of it can be obtained from certain textbooks and only the application of simple algebra is needed to make good use of the tools.

No attempt has been made to describe or to explain the methods used in the so-called "statistical" or "probability" methods. The author has chosen to point out that it can be applied to paper, just as it can apply to every industry, insofar as the handling of measurements is concerned. The method is not a "test" in itself, but a method of understanding the test. It is not a cure-all, but a signpost concerning a need for a cure. It does not tell how to remedy a situation, but it does point out more quickly and surely than any other method that a remedy may be needed. It is a sort of mathematical alarm clock to spur the user to action when, and only when, action is needed. It pays dividends in avoiding unnecessary action, as well as prompting action when it is necessary.

Some may wish to explore this method further. If you will inquire of the several universities in your area, you may learn of short courses, as at Stanford, Michigan, Purdue, Iowa, Carnegie Tech, and others. The American Society for Quality Control has offices at 305 East 43rd St., New York, 17, N. Y.

For those who wish to study "on their own," the authors choice of tests would be Grant's (McGraw-Hill) "Statistical Quality Control" as an introduction, along with the booklets Z1.1, Z1.2, and Z1.3 on Control Chart Methods issued by the American Standards Association of 29 West 39th St., New York. After these starters come such books as Smith's (McGraw-Hill) "Elementary Statistics and Applications" or Duncan's (McGraw-Hill) "Sampling Statistics and Applications," Kenney's (Van Nostrand) "Mathematics of Statistics," Croxton and Cowden's (Prentice-Hall) "Applied General Statistics," Waugh's (McGraw-Hill) "Elements of Statistical Method," and many others. The real meat of the statistical bill of fare is to be found in Shewhart's (Van Nostrand) "Economic Control of Quality of Manufactured Product," and Simon's (John Wiley) "Engineers Manual of Statistical Methods," but they can be heavy reading until one's appetite is whetted with a beginning of the subject.

Finally, do not expect the method to do the impossible. It is a tool whose edge is sharp or dull according to the care taken in its development. Like any other tool, the results depend on the skill of the user and his knowledge of where to apply it. Personally, the author is convinced that it is a tool that must be in the possession of each research and quality man in the paper industry, as well as other industries, in order to make real advances in quality and its production.

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TAPPI Annual Meeting

The following is the tentative annual meeting program of the Technical Association of the Pulp and Paper Industry to be held at the Commodore Hotel, New York, N. Y., on February 20–23, 1950.

Monday, February 20, 1950

10:00 a.m. *General Session (East Ball Room)*

A. E. Bachmann, *presiding*

1. Secretary's Report, by R. G. Macdonald
2. President's Address, by A. E. Bachmann
3. Tellers Report
4. Joint Textbook Committee Report, by R. S. Kellogg
5. "Radioisotopes in the Pulp and Paper Industry," by A. P. Schreiber, Tracerlab, Inc.

2:00 p.m. *Committee Meetings (Grand Ball Room)*

All committees of the Association will hold separate meetings to discuss committee projects and future plans.

Tuesday, February 21, 1950

9:15 a.m. *Paper making (Cylinder Machine) (East Ball Room)*

J. J. Harrison, *presiding*

1. "Vortraps as Applied to Paperboard Manufacture," by H. E. Ingalls, Nichols Engineering and Research Corp.
2. "Duotrol for Controlling and Refining," by William White, Shartle Bros. Machine Co.
3. "Rapid Length Classification of Pulp," by Arthur E. Reed, Gaylord Container Corp.

9:15 a.m. *Fibrous Agricultural Residues (Room B-C)*

S. I. Aronovsky, *presiding*

1. "Progress in the Use of the Test Corrugator," by N. F. Wilson, Alton Box Board Co.
2. "Determination of Yield Data on Strawboard," by B. F. Stahl, Terre Haute Paper Co.
3. "Improved Straw Pulp for Corrugating Paper," by H. M. Sutchiffe, et al.
4. "Straw Pulping in Europe," by Joseph E. Atchison, Economic Cooperation Administration

9:15 a.m. *Optical Properties (Room A)*

A. H. Croup, *presiding*

1. Panel Discussion on Gloss.

9:15 a.m. *Wet Strength (West Ball Room)*

K. W. Britt, *presiding*

1. "Mechanism of Retention of Beater Added Urea Resins," by M. N. Fineman and I. J. Gruntfest, Rohm & Haas Co.
2. "Neoprene Latex in the Paper Industry," by R. H. Walsh, W. W. Pockman, J. R. Gallaway, E. P. Hartsfield, and H. H. Abernathy, E. I. DuPont DeNemours & Co. Inc.
3. "Permanence of Wet Strength Paper," by C. S. Maxwell and W. F. Reynolds, American Cyanamid Co.
4. "The Instron Tensile Tester," by George S. Burr and Harold Hindman, Instron Engineering Corp.
5. "The Softening Mechanism of Paper Plasticisers," by P. E. Nethercut, Watervliet Paper Co.

2:00 p.m. *Water (Grand Ball Room)*

A. S. Erspamer, *presiding*

1. "The Water Problem," by Edward J. Cleary, Ohio River Valley Sanitation Commission
2. Paper by Harry Gehm, National Council for Stream Improvement
3. "The Waco Filter," by J. K. Perkins, Improved Paper Machinery Co.
4. "Operation of the Clariflocculator in White Water Recovery," by F. A. Eidsness, Infilco, Inc.
5. "Economic Considerations in White Water Treatment," by V. J. Calise, Graver Water Conditioning Co.
6. "Control of Sewer Losses," by John G. Dobson, Foxboro Co.
7. "Some Factors Affecting Slime Formation and Freeness of Board Mill Stock," by Willem Rudolfs and Nelson L. Nemerow, Rutgers University.

2:00 p.m. *Plastics (West Ball Room)*

E. C. Jahn and C. J. Straka, *presiding*

1. "Preparation and Properties of Various Papers for Lamination," by representative of the Forest Products Laboratory
2. "The Effect of Paper Type and Structure on the Physical Properties of Phenolic Resin Bonded Laminates," by M. P. Seidel, Westinghouse Electric Corp.
3. "The Effects of Paper Type and Structure on the Moisture Dimensional Stability of Phenolic Resin Bonded Laminates," by M. P. Seidel
4. "The Beater Addition Process for Producing Laminated Materials," by F. H. Snyder, L. Spiwak, and A. E. Moyer
5. "Resin Properties and Their Effects in Lamination," by C. B. Bennett, Catalin Corp. of America

2:00 p.m. *Chemical Engineering (Room B-C)*

J. R. Lientz, *presiding*

1. "The Role of the Chemical Engineer in the Pulp and Paper Industry," by G. W. E. Nicholson, Union Bag & Paper Corp.
2. "Chemical and Engineering Unit Operations in the Pulp and Paper Industry," by W. L. Badger, Consulting Engineer
3. "Stainless Steel Equipment for the Pulping Processes," by W. H. Funk and E. H. Wyche, Lukens Steel Co.

2:00 p.m. *Alkaline Pulping (East Ball Room)*

Henry Vranian, *presiding*

1. "The Pulping of Scrub Oak (Quercus Laevis) by the Kraft Process," by R. L. Harvin, C. W. Rothrock, and W. J. Nolan, University of Florida and G. B. Hills, Jr., St. Joe Paper Co.
2. "Chemical Cleaning of Black Liquor Evaporators," by H. H. Walthers, Dowell, Inc.
3. "The Operation of the Multi-Roll Beater in a Kraft Mill," by Milton R. Roberts, Hudson Pulp and Paper Corp.
4. "The Effect of Kraft Pulp Mill Wastes on Fish Life," by W. B. Van Horn, Institute of Paper Chemistry

Wednesday, February 22, 1950

9:15 a.m. *Water (East Ball Room)*

C. M. Connor, *presiding*

1. "Ground Waters," by William F. Guyton U. S. Geological Survey
2. "Process Water and White Water Filtration With the Automatic Backwash Sand Filter," by F. C. Schad, Hardinge, Co., Inc.
3. "Corrosion Control in Water Treatment," by W. Tanzola, W. H. and L. D. Betz
4. "Boiler Feedwater Treatment," by C. A. Brumley, Alhydro, Inc.
5. "Flow Instrumentation in the Pulp and Paper Industry," by G. Douglas Zimmerman, Fischer & Porter Co. (Canada) Ltd.

9:15 a.m. *Coating (West Ball Room)*

J. H. Heuer, *presiding*

1. "Starch and Its Application in Machine Coating," by Ralph W. Kerr, Corn Products Refining Co.
2. "Enzyme Conversion and Its Application to Machine Coatings," by D. A. Hughes and W. L. Craig, R. T. Vanderbilt Co.

Note: A motion picture film—Effect of Amylase on Starch—will be shown by Sutton Redfern, Standard Brands, Inc.

3. "The Reverse Roll Principle in Coating," by Lawrence W. Egan, Frank W. Egan & Co.
4. "The Insolubilization of Starch by a Lycoid-Mannogalactan Base Material," by Lawrence Gussman, E. F. Frisch, and R. E. Sweeney, Stein, Hall & Co.
5. "Casein and Its Application in Machine Coating," by J. W. Smith and R. T. Trelfa, Hercules Powder Co.
6. "The Rheology of Paper Coatings," by William R. Willets. Titanium Pigment Co.

Note: Papers not completed at this session will be presented at the Joint Coating-Graphic Arts Session in the afternoon

9:15 a.m. *Microbiological (Room B-C)*

R. F. DeLong, *presiding*

1. "The Preparation and Testing of Mold Resistant Wrapping Papers," by Louis C. Barail, U. S. Testing Co.
2. "Performance of Paper Machine Wet Felts. I. Preliminary Microscopic Observations of the Effect of Microorganisms on the Plugging of Felts," by Stanley Buckman, Buckman Laboratories
3. "Some Further Observations on *Penicilium Roqueforti Thom*," by John W. Appling and Conan D. Cash, Buckman Laboratories.
4. "Lethal Effect of Drier Roll Temperature Upon Bacteria," by B. F. Shema Institute of Paper Chemistry

2:00 p.m. *Coating and Graphic Arts (West Ball Room)*

R. H. Simmons and J. H. Heuer, *presiding*

1. "The Picking of Paper and Its Relation to Ink Tack," by Andries Voet and Claude F. Geffken, J. M. Huber Corp.
2. Paper by G. Cramer, Sinclair & Valentine Co.
3. "The Hercules Print Tester," by E. J. Barber and J. W. Davis, Hercules Powder Co.
4. Panel Discussion on Printing on Coated Papers

2:00 p.m. *Papermaking (Fourdrinier Machines) (East Ball Room)*

Noel R. Phillips, *presiding*

Symposium on Paper Machine Slices

1. "A Stain for Use in the Microscopy of Beaten Fibers," by Francis L. Simons, Crane & Co.

2A. "Rag Content Papers," by Robert W. Pattison, Cellulose Fibre, Inc.

2B. "Lightweight Papers," by F. O. Boylon, Crown Zellerbach Corp.

2C. "Newsprint," by Vernon P. Tipka, News Print Service Bureau

2D. "The Ideal Slice," by S. A. Staege, Black-Clawson Co.

2:00 p.m. *Semichemical Pulping (Room B-C)*

R. M. Drummond, *presiding*

1. "The Manufacture of Chemigroundwood Pulp from Hardwoods," by C. E. Libby and F. W. O'Neil, N. Y. State College of Forestry
2. "Effect of the Presence of Bark in Semichemical Pulping," by E. L. Keller, Forest Products Laboratory
3. "Effect of Mild Treatments With Sodium Hydroxide in Producing High Yield Pulps from Aspen," by K. J. Brown and J. N. McGovern, Forest Products Laboratory
4. "Neutral Sulphite Pulping in the Chemipulper," by R. G. Goodwin, Paper & Industrial Appliances, Inc.

9:15 a.m. *Containers (Room B-C)*

H. T. Barker, *presiding*

Symposium on Paper Shipping Case Performance

1. "An Unscientific Way to Scientific Help in Packaging," by C. S. Macnair, Acme Steel Co.
2. "Some Aspects of Container, Handling in Rail Transportation," by E. J. Dahill, Association of American Railroads
3. "Suggested Methods for Testing Corrugated Shipping Cases," by E. H. Balkema, Colgate-Palmolive-Peet Co.

9:15 a.m. *Acid Pulping (West Ball Room)*

G. H. McGregor, *presiding*

1. "Relation Between Yield and Properties of Spruce and Aspen Sulphite Pulps," by J. N. McGovern, Forest Products Laboratory
2. "Ammonia-Base Sulphite Pulping of Hardwoods," by E. F. Thode and Y. H. Lee, University of Maine
3. "Proven Methods of Screening Maximum Quantities of Quality Pulp," by H. F. Schenk, Magnus Metals Corp.
4. "Circulation Systems and Sulphite Pulping," by J. M. Wilcox, Electric Steel Foundry
5. "Use of Sulphite Waste Liquor in Cement," by E. W., Scripture Master Builders Co.

9:15 a.m. *Chemical Products (Room A)*

Arthur Pollak, *presiding*

Program on Tall Oil to be announced

12:45 a.m. *Annual Luncheon*

1. Presentation of the TAPPI Medal to George H. Mead, Mead Corp.
2. "The Marshall Plan and the Pulp and Paper Industry in Europe," by Joseph E. Atchison, E.C.A. Pulp and Paper Division

Note: This program is subject to change prior to the annual meeting. Committee chairmen and authors of papers are urged to advise R. G. Macdonald, *Secretary*, TAPPI, 122 East 42nd St., New York 17, N. Y., immediately concerning errors, omissions, and other changes that should be made in the final program. These changes will be published in the February issue of *Tappi*

College Alumni Luncheons

Massachusetts Institute of Technology, Tues., Feb. 21 at the Engineer's Club, 32 West 40th St.
Syracuse University, Wed., Feb. 22 in the Hendrik Hudson Room, Hotel Roosevelt.
University of Maine, Wed., Feb. 22 in the South Room, Hotel Commodore

Student Members

The recent ballot dealing with a change in the Association's Constitution resulted, with only an occasional dissenting vote, in a change in membership classification. Beginning in January the junior membership grade will cease to exist and the new grade of student member will come into being. This takes care of the intent of subsidized membership in that it provides the college student or the very young man in the mill an opportunity to benefit from the work of the Association at a time when he needs such help but cannot afford to pay more than a nominal amount to obtain it. Since TAPPI is about the only society of its kind to refrain from increasing its dues, which are still the same as they were in 1921, the present inflated dollar enables even recent college graduates to pay his share of the Association expense without being unduly burdened.

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In your business you can't sweep dirt "under the rug"

There's no place for it to hide in a sheet of paper

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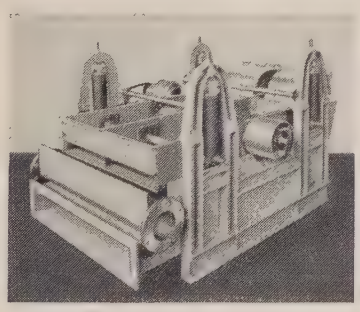
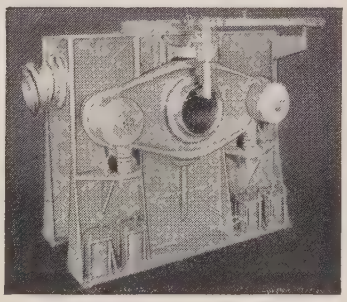


Bird Jonsson Screens for taking the dirt, knots, bark, shives, etc., out of pulp before it is broken up into hard-to-remove specks.



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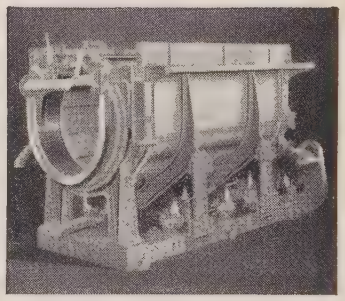

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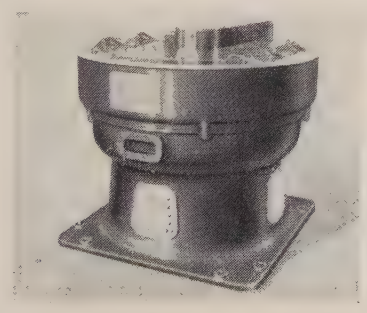

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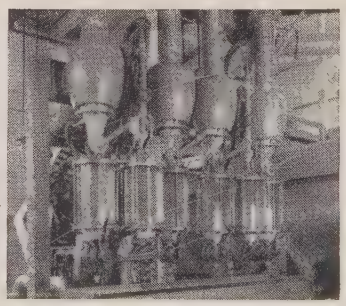

PERSONAL MENTION

New TAPPI Members

John L. Aitkens, Assistant Resident Engineer, Rayonier, Inc., Grays Harbor Div., Hoquiam, Wash., a 1938 graduate of Louisiana State University with an M.S. degree.

Jean Arguillere, Director General, Papeteries de la Chapelle, St. Etienne du Rouvray, France, a 1929 graduate of Ecole Polytechnique, Paris.

Caeser Bang, Jr., Managing Director, A/S Greaker Cellulosefabrik, Oslo, Norway, a 1925 graduate of Zurich, Switzerland.

Carl A. Bjorkbom, Head Librarian, Royal Institute of Technology, Stockholm, Sweden.

Robert G. Bohn, Chief Engineer, Michigan Carton Co., Battle Creek, Mich., a 1914 graduate of Armour Institute.

Per Bro, Graduate Student, Dept. of Chemical Engineering, Yale University, New Haven, Conn.

K. E. C. Buyn, Chemical Engineer, Joh. Enschede & Zonen, Haarlem, Netherlands, a 1938 graduate of Technical University, Delft.

Edgar K. Carpenter, Engineer, The Terre Haute Paper Co., Terre Haute, Ind., a 1946 graduate of Rose Polytechnic Institute.

Jerm T. Christiansen, Project Engineer, Kraft Mill, N. Z. Forest Products Ltd., Auckland, N. Z., a 1934 graduate of Technical University of Helsinki, Finland.

Irwin Cohen, Vice-President, Bork Bros., Inc., Union City, N. J., a 1938 graduate of the University of Virginia.

John W. Davidson, Technician, American Can Co., Maywood, Ill. Attended the University of Wichita.

Walter B. Eklund, Sales Manager, Warren Steam Pump Co., Inc., Warren, Mass., a 1936 graduate of Worcester Polytechnic Institute.

John P. Gerhauser, Chemist, Appleton Wire Works, Inc., Appleton, Wis., a 1922 graduate of the University of Wisconsin.

Samuel I. Hershman, President, I. Hershman & Co., Inc., New Haven, Conn., a 1913 graduate of the University of Michigan.

Charles E. Hill, Engineering Trainee, The Pusey & Jones Corp., Wilmington, Del., a 1947 graduate of Duke University.

Georg Jayme, Professor, Technische Hochschule, Darmstadt, Germany, a 1922 graduate of Technische Hochschule, Darmstadt, with a Ph.D. degree.

John M. Kelly, President and Treasurer, Kelly-Forsyth Corp., Ithaca, N. Y. Attended Syracuse University.

Lawrence Leney, Instructor, New York State College of Forestry, Syracuse, N. Y., a 1948 graduate of New York State College of Forestry with an M.S. degree.

George R. Lydick, Resident Engineer, Crossett Paper Mills, Crossett, Ark., a 1934 graduate of Purdue University.

Mark G. Magnuson, Jr., Technical Sales, Titanium Pigment Corp., Cleveland, Ohio. Attended Massachusetts Institute of Technology.

Rutger-Martin-Lof, Mill Manager, Aktiebolaget States Skogsindustrier, Karlsborgsverken, Sweden, a 1936 graduate of Kungl. Tekniska Hogskolan.

Russell A. McCoy, Jr., Contract Manager, C. M. Guest & Sons, Greensboro, N. C., a 1933 graduate of Virginia Military Institute.

Hendrik W. Meijer, Managing Director, O. J. Meijer's Dextrinefabrieken N. V., Veendam, Holland.

Lawrence R. Mitchell, Sales and Service Engineer, John W. Bolton & Sons, Inc., Lawrence, Mass. Attended Case School of Applied Science.

Onni O. Ojala, Editor-in-Chief, *The Finnish Paper and Timber Journal,* Helsinki, Finland, a 1920 graduate of the University of Helsinki.

Royal D. Packard, 28 Mayo St., Dover-Foxcroft, Me., a 1926 graduate of Massachusetts Institute of Technology.

Francois X. Pfulg, Consulting Engineer and Representative, Cologny/Geneve, Switzerland. Attended Ecole Spec. des Travaux Publics, Paris.

Warren G. Printz, Engineer, The Manchester Machine Co., Middletown, Ohio, a 1949 graduate of the University of Cincinnati.

Robert W. Ramsdell, Technical Sales, Penick & Ford Ltd., Inc., Cedar Rapids, Iowa, a 1949 graduate of the University of Maine.

George W. Read, Salesman, E. I. duPont de Nemours Co., Inc., Wilmington, Del., a 1943 graduate of the University of Louisville.

John S. Richards, Librarian, Seattle Public Library, Seattle, Wash.

Odell K. Sanders, Chief Inspector, The Champion Paper and Fibre Co., Pasadena, Texas, a 1935 graduate of The Rice Institute.

Adalbert J. Schierl, Secretary-Treasurer and General Manager, Whiting-Plover Paper Co., Stevens Point, Wis.

S. Bertil Segring, Works Manager, Irish Wallboard Co. Ltd., Athy, Co., Kildare, Ireland, a 1928 graduate of Royal University of Technology, Stockholm.

Kurt H. Siecke, Consulting Engineer, Portland, Ore., a 1921 graduate of the University of Illinois.

Stanley W. Trosset, Jr., Chemist, Gardner Board & Carton Co., Middletown, Ohio, a 1948 graduate of Transylvania College.

Blanche B. White, Section Head, Celanese Corp. of America, Summit, N. J., a 1925 graduate of Goucher College, with an M.S. degree from the University of Chicago in 1927.

Harry E. Zortman, Jr., Assistant Chemist, Southern Kraft Div., International Paper Co., York Haven, Pa., a 1949 graduate of Lehigh University.

TAPPI Notes

Henry R. Adams, formerly of the Dunn Paper Co., is now Technical Director, Bloedel, Stewart & Welch, Ltd., Pulp Div., Port Alberni, B. C.

Harold V. Brady, Vice-President and General Manager, Negley Bag & Paper Co., has transferred from San Antonio, Texas, to W. Monroe, La.

George W. Brumley is now Resident Manager, St. Marys Kraft Corp., St. Mary's, Ga.

Charles H. Chapman, Chemist, Hercules Powder Co., has been transferred from Atlanta, Ga., to Portland, Ore.

Theodore E. Detcher, formerly of G. D. Jenssen Co., Inc., is now Chemical Engineer, New Products Development Dept., The Barrett Div., Allied Chemical & Dye Corp., Evans Mills, N. Y.

Theodore P. Duver, formerly of the Dilts Machine Works is now Sales Engineer, Export Dept., Shartle Div., Black-Clawson Co., Middletown, N. Y.

Joseph Edwards is now Manager of the Paper Div., Price Bros. Co. Ltd., Kenogami, Que.

Myron Flowtow, formerly Manager of Production, Central Paper Co., is now with the Mohawk Paper Mills, Cohoes, N. Y.

Durward B. Geffken, formerly of the Empire Box Co., is now Chief Chemist, Oswego Falls Corp., Fulton, N. Y.

CONVENTION DAILY

published by PAPER & PAPER PRODUCTS for the Annual

TAPPI CONVENTION

February 20-23 1950

HOTEL COMMODORE, NEW YORK

For many years PAPER & PAPER PRODUCTS (Regularly published semi monthly) has published the TAPPI CONVENTION DAILY. As a real *tabloid size* newspaper it goes to press at 2 AM each morning and greets the delegates at breakfast. The DAILY is distributed to delegates at their meeting places, and to all convention hotels in the Grand Central Zone. Well illustrated with live news photos, it covers completely the agenda of meetings, programs, personnel items, room numbers and other editorial matter of interest to the paper men present.

The DAILY is produced by the same staff that regularly edits the other Walden-Mott publications—a staff, therefore, which is of sufficient size to do the job right.

Four issues will be published, the first on Monday morning February 20th and on each succeeding morning Tuesday, Wednesday and Thursday.

The DAILY provides its advertisers with CONCENTRATED CIRCULATION among the important men of the industry—at a time when they are most receptive.

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Otto Goeppinger has resigned as plant manager and general superintendent of The Marcalus Mfg. Co., East Paterson, N. J. and has resumed his paper mill consulting practice at 11 W. 42nd St. New York, N. Y. While at the Marcalus mill Mr. Goeppinger redesigned No. 1 paper Machine designed and operated a new parchurentizing machine, and operated the entire converting plant.

Karl-Folke Gothner, formerly of the Camp Mfg. Co., is now Chemical Engineer, Union Bag & Paper Corp., Savannah, Ga.

H. Maxwell Hughson, Research Engineer, Provincial Paper Ltd., has been transferred from Port Arthur, Ont., to Georgetown, Ont.

John R. Leggett of the Barrett Division is now Maintenance Supervisor at their Philadelphia plant.

Russell L. Lewis, formerly of the St. Regis Paper Co., is now Development Chemist, Ohio Boxboard Co., Rittman, Ohio.

John M. McEwen of the Pulp Div., Weyerhaeuser Timber Co., has been transferred from Longview to Everett, Wash.

R. A. Marrone, formerly of Cooch Behar Paper Mills is now Manager, Star Paper Mills, Saharanpur, U. P. India.

M. Howard Morley, Industrial Consultant, is now located at 2718 North East 19th St., Fort Lauderdale, Fla.

Harold S. Morse is now Superintendent of Coating Preparation, Maine Seabord Div., St. Regis Paper Co., Bucksport, Me.

Henry J. Perry is now Editor, *Paper Trade Journal,* New York, N. Y.

William S. Richardson, formerly of the N. Y. State College of Forestry is now with S. D. Warren Co., Cumberland Mills, Me.

S. Bertil Segring, formerly Works Manager, Irish Wallboard Co. Ltd., Kildare Co., Ireland, is now a consultant in Landskrona, Sweden.

Joseph W. Shimp, formerly of the Marinette Paper Co., is now Paper Mill Superintendent, Scott Paper Co., Chester, Pa.

Charles M. Sigvart, formerly of the Marinette Paper Co., is now on the Technical Service Staff, Scott Paper Co., Chester, Pa.

George Sivola, formerly of Enso-Gutzeit O/Y is now with Rauma-Raahe O/Y, Rauma, Finland.

Edgar F. Smith, formerly of Polamold Research Laboratories is now with Brown-Bridge Mills, Troy, Ohio.

Kurt Suter of Peter J. Schweitzer, Inc., has transferred from Spotswood, N. J., to Mount Holly Springs, Pa., where he is Mill Manager.

Aubrey T. Taylor is now Vice-President, National Container Corp., of Virginia, Big Island, Va.

James S. Tipka, formerly of Scott Paper Co., is now Process Control Engineer, Marinette Paper Co., Fort Edward, N. Y.

Thomas W. Toovey, formerly of Cheney Bigelow Wire Works is now with Sherbrooke Machineries Ltd., Montreal, Que.

V. Edwin Ware, formerly of the Rust Engineering Co., is now Plant Engineer, Marathon Corp., Menominee, Mich.

Lawrence T. Waterman of the St. Regis Paper Co., has transferred from Tacoma, Wash., to Deferiet, N. Y., where he is Asst. to the Vice-President, Kraft Paper Division.

W. T. Webster is now Vice-President and General Manager, National Container Corp., Jacksonville, Fla.

F. Leroy Zellers is now Mill Manager, Chillicothe Paper Co., Chillicothe, Ohio.

* * *

J. Shartle Brookover has succeeded J. L. De Tar as the official representative of Downingtown Paper Co. in TAPPI.

W. G. Reynolds has succeeded J. W. Warner as the representative of Gulf States Paper Co.

Lucien G. Rolland has succeeded Jean Paul Rolland as the representative of the Rolland Paper Co. Ltd.

F. W. Hochmuth, Manager of Engineering, Pulp and Paper Mill Equipment Dept., has succeeded A. L. Hamm as the official representative of Combustion Engineering-Superheater, Inc., in TAPPI.

A. C. Junge, Manager of Bulk Starch Sales, has succeeded George F. Corson as the representative of Clinton Foods, Inc. (formerly Clinton Industries, Inc.).

Richard M. Radsch, Vice-Pres. in charge of Sales has succeeded H. P. Madsen (deceased) as representative of the Appleton Machine Co.

Richard D. Kehoe

Richard D. Kehoe, President of Paper and Industrial Appliances, Inc., New York, N. Y., died suddenly at Miami Beach, Fla., on December 6, 1949. Mr. Kehoe, who was born in New York City on July 9, 1886, was well known throughout the pulp and papermaking world for his work in the development and sale of many kinds of machinery. He attained his greatest prominence in connection with a pulp drying and shredding machine and recently as co-inventor of the Chemipulper. He was a member of TAPPI and contributed a number of technical reports at its meetings. Funeral services were held at St. James P. E. Church in New York City on December 8. He is survived by his wife, Mrs. Margaret S. Kehoe, and three sons.

William H. Savery

William H. Savery, President of the Harpers Ferry Paper Co. of West Virginia, died at his home in Wilmington, Del., on June 12, 1949, at the age of 83. Following a period of seventeen years with the Pusey & Jones Corp. in Wilmington, he formed the Shenandoah Pulp Co., at Harpers Ferry, W. Va., and continued with this company which later became the Harpers Ferry Paper Co., until the 30's when the mill discontinued operation. He was a member of TAPPI since 1917.

John C. Monty

John C. Monty, Mill Manager of the Gatineau Mill of the Canadian International Paper Co., died at his home in Gatineau, Que., on October 19, 1949. He was born at Glens Falls, N. Y., on December 2, 1887 and attended Columbia University.

Since 1903 Mr. Monty worked as a machine operator, superintendent and manager of such companies as the Carthage Sulphite Pulp Co., West Virginia Pulp and Paper Co., Great Northern Paper Co. (where in 1919 he operated the first newsprint machine to exceed 1000 ft. per min.), Anglo-Newfoundland Development Co., and St. Regis Paper Co. He joined the International Paper Co. in 1927 at New York City and was connected with the establishment of the Canadian mills. In 1937 he became mill manager of the Gatineau mill. In World War I he was an infantry captain in the A.E.F. and was a member of TAPPI since 1930.

Fletcher P. Thornton

Fletcher P. Thornton, First Vice-President and Director of Stowe-Woodward, Inc., Newton Upper Falls, Mass. and W. E. Greene Corp., New York, N. Y., died suddenly at his home in Summit, N. J. on Sunday, December 18, 1949. Mr. Fletcher was born in Baltimore, Md., January 11, 1896. He is survived by his wife and three sons, Fletcher P. Jr., James S., and Peter Thornton.

Industry Notes

Paper and Paper Products (Walden Sons & Mott) has again kindly offered to provide each individual attending the TAPPI Annual Meeting (February 20–23, 1950) with a complete list of the daily registration.

* * *

The National Board of Fire Underwriters has just issued its Research Report No. 7 "Precautionary Fire and Explosion Safeguards in the Use of Chlorine Dioxide for Industrial Bleaching." Copies may be obtained upon request from the Board at 88 John St., New York 7, N. Y.

* * *

Farrel-Birmingham Co., Inc., Ansonia, Conn., has issued a new 16-page bulletin (No. 116) which describes how chilled iron rolls are made and features emphasis on good workmanship.

* * *

American Defibrator, Inc., Chrysler Bldg., New York 17, N. Y., announces a new bark press, now in commercial production, which reduces the moisture content of wet bark to 50% or lower. In this state, the bark is combustible and has about the fuel value of coal. The screw feed principle is used. Wet bark, containing about 85% water is fed through a hopper to a tapered throat where it is compressed by a screw. Present installations handle about 5 tons (moisture-free) per hour.

* * *

John A. Marzall of Chicago has succeeded Lawrence C. Kingsland as U. S. Commissioner of Patents. Mr. Kingsland has returned to his private law practice in St. Louis.

* * *

Ellis F. Parmenter and *Cornelius Betten, Jr.*, have removed from Canton, N. C., to Hamilton, Ohio, to continue their work as members of the Pulp Research Laboratory of the Champion Paper and Fibre Co. A previous item (page 82A, November *Tappi*) may have given incorrect connotation. Champion's General Research Laboratories, which have always been located at Hamilton are under the direction of *W. J. Montgomery*, Director of General Research. The Pulp Research Laboratories were recently moved from Canton to Hamilton with *W. Phalti Lawrence* continuing as Director of Pulp Research with *Malcolm Lyon* as his assistant.

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Positions Open

P42-50. Paperboard and box mill in New England. Chemist for small, well-equipped laboratory. Applicants should have had experience in paperboard manufacture and training in routine analysis and testing.

P43-50. Director of research and development. Kraft pulp and paper mill in South.

P44-50. Technical sales service department. Mid-west starch manufacturer. Chemistry, engineering, or pulp and paper school education. Mill experience, good personality. Considerable traveling.

P45-50. Sales and technical service representative. Mid-west territory. Control of microorganisnis in paper mills and other industrial plants. Man with background of sales experience with education in engineering and microbiology. Preliminary training will be given.

Positions Wanted

E56-50. Technical control. If you want your process variables controlled, know where your losses are, eliminate those wild cooks and bleaches, know whether or not you are meeting customer specifications before half the order is on the reels, you need the services I can offer. 12 years' experience research and production control.

E57-50. Technical or production director. 18 years' experience on paper and board, coatings and paper treatment. Cost conscious. Prefer midwest location.

E58-50. Chief or plant engineer. Registered mechanical engineer, 37, married, wishes position in the South. Preventive maintenance, lubrication, construction experience.

E59-50. Technically trained superintendent, 36. Fourteen years' experience with same firm in research and development, papermaking and paper coating. Now employed. Desires position in production or sales service in paper or allied industries in the East.

E60-50. Production and personnel management: 15 years experience in sulphite pulping, pulp bleaching, and fine paper manufacture. Practical managerial experience with technical background.

Replies should be addressed to box number, % *Tappi*, 122 East 42nd St. New York 17, N. Y.

Collective Bibliography 1946–1950

Clarence J. West, Chairman of the TAPPI Bibliography Committee advises that he is planning to prepare a five-year collective Bibliography of Papermaking covering the years 1946–1950. The annual Bibliography for 1950 will not be published but references for that year will be included in the collective volume. The patents for 1950 will be published in the 1951 volume.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Pacific

Tacoma Meeting

The Pacific Section convened at 2:00 p.m., October 25, 1949, at the Towers, Tacoma, Wash. Walter F. Holzer of Crown Zellerbach Corp. opened the meeting and introduced L. F. Maybach of the Camas Mill who served as moderator of the panel on "Instrumentation."

The first paper, Electronics in the Paper Industry, was presented by S. H. White of General Electric Co., Seattle. The subject was chosen because there has been many new developments along the electronic line that are now being put to good use in industry and could be applied to the paper industry in most cases. Mr. White explained the basic elements of electronics and the functioning of the several types of vacuum and gas filled tubes. He illustrated some of the common applications in industry such as the direct use of photo electric cells and vacuum tube amplifiers in smoke control on industrial stacks, counting and register control of printed sheets and paper products. This photo electric cell also allows direct measurement of brightness and color including analysis of color of any material. The indirect use of the photo electric cell was explained in the "Servel System" which allows accurate measurements of extremely weak electrical signals, where no power may be taken from the system to operate the measuring device.

The use of x rays and Beta rays in measuring continuously the thickness of steel strips of paper webs was of special interest as was high-frequency drying of such material as textiles where other means of drying failed to control moisture content to the limits necessary in that industry.

Mr. White pointed out that practically every physical quality of any product and many chemical qualities could now be measured and the problem was only to choose the proper method and make the right application of the principles known. The greatest difficulty is present in developing a "sensing unit." After a satisfactory sensing unit is applied to a process, amplification of the output of the "sensing unit" and automatic control of the process is a matter of routine. It was pointed out, however, that this equipment is sometimes costly and often it is economically unsound to purchase and install the equipment, but that the cost will decrease as industry purchases more such equipment and the demands of industry will determine future advancements in this field.

Mr. White expressed a very basic concept of instrumentation when he stated "the application of instruments to a process should not be made with the purpose of replacing an operator, but with the purpose of creating a better product or a more uniform product. The operator must know the process thoroughly, and *what*, *why*, and *how* the instruments are affecting the product."

"pH Control on Paper Machines" was presented by Howard Hall, Crown Zellerbach Corp., Camas. This subject was chosen as pH control on paper machines is fast becoming a must to meet the more exacting demands of the paper users. Mr. Hall defined pH and described the curve obtained in plotting ion concentration against pH number. He then listed some of the advantages of closely controlled pH, among them being, lower costs of alum, more uniform color, better control of sizing and loading in the sheet, and more uniform operation of machine proper.

The physical setup was described with certain "musts" that are necessary to good operation of this equipment. These necessary conditions must be met. The electrodes making up the primary measuring device must be not over seven or eight seconds in flow time from the point at which the alum is introduced. The instruments must be kept dry and shielded from stray E.M.F. The controller must be of the proportional type with reset so that operators can obtain the required pH with the minimum effort on their part.

It was brought out that a check every eight hours was necessary to assure that the pH instrument was operating correctly. This check is made by the Technical Control Department, and if the recorder varied as much as 0.3 pH from that found by the laboratory check that fact was reported to the shift foreman who would make corrections to compensate for the error, or call the instrument department if he wanted the instrument fixed. It was noted that the usual failure was a slow change due to coating forming on the glass electrode and this change would show on the checks before any large errors had developed. The check sample is normally taken at the wire pit, but it should be noted that wire pit pH will differ from head box pH by as much as 0.9 pH so that headbox pH is checked in cases where wire pit pH does not coincide with the recorder controller.

"Consistency Control Using Photo Electric Cells" was the title of the paper presented by Herb Peterson of Weyerhaeuser Timber Co., Longview. This application of the photo electric cell was pioneered by Mr. Peterson, and he successfully operated such a device for some fifteen years. Mr. Peterson described the physical setup of the light source, the sample tube and the photo electric cell and laid down the following requirements for successful operation. The stock must be well mixed and of uniform distribution in the water that is free of bunches or bundles of stock. The sample rate must be uniform and steady. Turbulence will upset the measuring device.

The range of this type of measuring device is limited. On unbleached sulphite, the range is from 0.25% to 0.75% consistency. The best results are obtained at between 0.3% and 0.4% consistency. It was brought out that if the light source were adjusted to give an output of 100 micro amps by passing the light through a clear water sample, the output would be only 25 micro amps if a sample of 0.4% were used. Since the ranges of this type of instrument coincide with the desired conditions for screening, its application to that process is a natural and the results obtained are far better than straight hand control.

Forrest Williams of Crown Zellerbach Corp., Camas, presented a paper on Sulphur Level Control in Rotary Sulphur Burners. Charts were shown depicting the different conditions maintained with and without automatic level control. It was noted that gas temperatures and gas analysis were much more even and regular with automatic level control. The sulphur melting and burning equipment of the Camas Mill was described, and it was noted that five small burners were in use with a single header cooler where the changing of any one burner would affect all five burners. The limits of control were described as being plus or minus $1/4$ in. and the range of the liquid level controllers 0 to 10 in. of water. Slides showing the construction of the sulphur control valves and bubble pipe system illustrated the operation of this system.

"The Measurement and Control of Chlorine" was presented by Brian L. Shera of Penn Salt Mfg. Co., Tacoma. This paper was presented to give a better understanding of some of the difficulties met in handling chlorine. The equipment necessary to handle chlorine was described by Mr.

Shera and the function each part played. First, the special tank cars which can withstand 300 p.s.i. pressure and the unloading equipment. Second, the unloading is done by pumping air into the car and forcing the chlorine out through a syphon pipe. It was noted here that extreme care must be used to keep this padding air dry. To avoid corrosion and other troubles, water must be kept away from chlorine at all times.

The use of gas bells to take care of the expansion of liquid chlorine was described and locations where safety heads are needed to protect evaporators. It was pointed out that high loops should be installed ahead of the system where chlorine is bubbled into water to prevent the syphoning of water up into the chlorine system. Electric stop valves to shut off chlorine in cases of power failure were described as very desirable as well as automatic air purge on shutdowns of chlorine systems. Mr. Shera showed slides of batch and continuous chlorinating systems and NaOH systems, showing the equipment normally used to measure the materials in each case. The main point brought out in this paper was that chlorine systems to operate satisfactorily must be kept completely free of water or water vapor.

After dinner, Howard W. Morgan of Weyerhaeuser Timber Co., Tacoma, described his early years in the Maine woods where he learned by experience that the tall tales told by Buff Natwick were true because of the many similar experiences he has had himself in that area. I believe we have found the source of some of the Paul Bunyan stories, and I'm sorry these stories aren't a matter of record.

L. F. Maybach, Crown Zellerbach Corp., Camas, Wash.

Longview Meeting

The joint meeting at Longview, on December 6, 1949, of the TAPPI Pacific Section and the Pacific Coast Division of the Superintendents Association attracted a total attendance of over two hundred members of the two groups to take part in a comprehensive survey and discussion of "Converting Problems." The technical program, which was arranged and conducted by Carl Fahlstrom, Longview Fibre Co., was the first occasion at which West Coast technical men have explored this important phase of the industry.

A résumé of the papers presented at Longview follows.

(1) "Quality Control Through Consumer Acceptance Inspection" by James B. Brown and R. L. Cochran, Western Waxed Paper Co., North Portland, Ore. This paper was presented by James B. Brown. Speed-up of production and the necessity of meeting stiffer requirements has made it necessary for paper manufacturers to improve their control systems. The Western Waxed Paper Co. of Portland has attempted to meet this control problem by a method which they call *Consumer Acceptance Inspection.* Their quality control system involves three major steps:

1. Education of the operators to know the specifications desired by the consumer and to assume the responsibility of producing them.
2. Placing identification marks on all possible items of manufacture so that defects can be referred back to the operators who made them.
3. Spot checks on materials before shipment, taken at random, to get a look at the product as the consumer will see it.

Their program puts special emphasis on giving the machine operators the responsibility for product quality, and making their tests in such a manner that they will obtain a consumer's viewpoint of the product. The test results are reported so that both management and the machine operators obtain a full picture of the results.

(2) "Converting Begins on the Paper Machine" by R. C. McKee of the Institute of Paper Chemistry, Appleton, Wis. Present methods of evaluation of paper and paperboard are inadequate for the prediction of the quality of converted

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boxes. Adequate methods of evaluation cannot be developed until further basic information relating the components to the finished product is available. High-quality materials, good conversion, and knowledge of the use for which the product is intended are necessary for the manufacture of a good product. A progressive container program consists of: (1) Review of the literature, performance data, and test methods; (2) Instrumentation study covering existing methods, development of new methods, and establishing laboratory-field relationship; (3) Research and development in the fields of materials and fabrication; field studies; and application of results. Following this program the Container Section of the Institute of Paper Chemistry has developed a single flute test that shows considerable promise of being a test by which the flat crush of corrugating medium can be predicted.

(3) "Fabricating Quality and Performance into corrugated Shipping Containers" by A. O. Parson, Longview Fibre Co., Longview, Wash. The responsibility for obtaining quality and performance in corrugated shipping containers has shifted from the board manufacturer alone to the board manufacturer and the converter. Good quality rolls of uniform board are required. The converter must check the effect of each step in the operation on the final quality of the finished container. Tests that can be used as an aid in evaluating the effect of each operation are caliper, moisture, weight, adhesion, mullen, compression, puncture, crush, drum, drop, score tear, and impact. Only by constant watchfulness to prevent damage at every contact or pressure point in the corrugation, printing, slotting, and joining can quality containers be fabricated.

(4) "Technical Control of Converting Operations" by J. A. Butterick, Crown Zellerbach Corp., Camas, Wash. The paper discussed the part played by Technical Control in assuring customers of sufficient volume of top quality product delivered at the time requested. Technical Control assistance in meeting these objectives at the lowest possible cost would be obtained by setting up specifications of two categories as follows: Physical aspects as weight, count per unit, satisfactory service, etc.; Intangibles such as appearance, eye appeal, etc.

Technical Control's principle assistance to management was grouped into the following classifications: Determination of reasons for cost increase; Causes, extent, and corrective action necessary to prevent storage damage; Reasons for and recommendations as to reduction of abnormal waste in conversion operations; Interpretation of consumer demands; Supervision of trial runs on new or proposed production; Rejection of unsatisfactory production as early in the process as possible; Checking and answering complaints to the satisfaction of the consumer.

Consumer satisfaction would be further assured by finished product inspection from shipping storage and by testing product purchased on the open market. Specifications would also be set up with the consumer's view point in mind. Competition demands that Technical Control not only assure customer satisfaction but also preference for the product being produced.

(5) "Material Handling Problems in Paper Converting" by R. P. Wollenberg, Longview Fibre Co., Longview Wash. It is pointed out that a large part of the labor in converting consists in moving materials around. To minimize this, paper should first be put in large loads. Increase of roll diameters is one method which helps minimize both labor and wastage if suitable machinery is provided to handle them. Palletization of small rolls also permits power handling. Power handling whether by fork truck, crane, or conveyors should be injected insofar as possible for every move through the various converting processes. The limitation of existing buildings such as height to underside of trusses, door size, posts, and narrow aisles must be dealt with often by major changes, if economics so dictate.

Production shops often lend themselves to conveyors. Job shops such as box plants usually require more flexible methods such as fork trucks. Maximum use of vertical warehouse space is made by use of powered lift equipment and this gain usually more than offsets the loss due to increased aisles required. New trend toward handling jumbos with revolving roll grabs and storing on end appears to offer more convenient storage, safer shipping and less damage in handling.

(6) "Management Problems in Converting Operations" by B. F. Warren, Crown Zellerbach Corp., Camas, Wash. Mr. Warren opened by praising meetings of the TAPPI type where ideas are freely exchanged, stating that this was an aid to better and more economical production.

The 5 M's of management are (1) materials, (2) men, (3) machines, (4) money, and (5) motivation.

Motivation is management's most pressing problem, motivation being the creation of favorable sentiment and attitudes among employees to make them want to do the best job at the lowest cost. Fear is one motive that has been used in the past, but it should be avoided. Motivation is a secret art with each manager, each manager having his own ideas and not passing them on to his successor. Each new manager must begin from the bottom developing his own motivating techniques.

It was suggested that a long-range research program be set up cooperatively to investigate and develop "motivation." The results then would give each manager a basis from which to work.

Following the afternoon technical meeting members of the two associations were entertained at a reception honoring the newly elected officers of the Pacific Coast Division of the Superintendents Association.

Charles E. Ackley, 2nd Vice-President of the Superintendents Association presided at the dinner held at the Hotel Monticello and introduced the evening speaker, David B. Simpson, Norris Beggs & Simpson, Portland, Ore. Mr. Simpson presented a factual review of pending legislation in Congress on the "Columbia Valley Administration" and pointed out the inherent dangers to the Pacific Northwest area which could result from such legislation.

R. M. True, *Secretary*, Pacific Section TAPPI

Ohio

"The Legal Phases of Water Pollution Control in Ohio" was discussed by F. H. Waring of the Ohio Department of Health as he addressed 144 members and guests of the Ohio Section at a dinner meeting at the Manchester Hotel in Middletown on December 8th. After a short business meeting, Chairman Art Thurn presiding, the speaker was introduced by C. E.

Speakers Table, Ohio Section Meeting, Dec. 8, 1949. L to R—George Manos and Dave Stewart, Ohio State Board of Health, C. E. Ahlm, Chillicothe Paper Co., Bruce McDill and F. H. Waring, O.S.B.H., Arthur Thurn, Champion Paper & Fibre Co., Chairman, TAPPI Ohio Section, John Clouse, Oxford-Miami Paper Co., Corresponding Secretary, and H. A. Smith, Mead Corp., Program Chairman.

Ahlm of the Chillicothe Paper Company. Mr. Waring's talk follows.

"*State Legislation* The first legal step taken by Ohio looking toward control of water pollution took place in 1893 when the requirement was imposed upon municipalities to submit plans to the State Department of Health for any *proposed* installation of sewerage and sewage treatment works. (Sec. 1240 G.C.—Amended and clarified in 1925.)

"After Louis Pasteur's discoveries, people became more conscious that water could convey disease organisms. People were requesting a clear water. By clarification and filtering some disease organisms were removed. The art of water purification was started in Louisville in 1898. This was a clarification and filtering process. Cincinnati followed with a plant in 1907 and Columbus in 1908. The trend is toward the use of surface water for potable supply. Of the people in Ohio, 75% are served water from a surface source.

"Next in 1908 there was enacted the so-called Bense Act (Sec. 1249–1261, incl., G.C.) which provided, upon proper petition or complaint, for action by the State Department of Health comprising investigation, finding, hearing, and order for correction of water pollution resulting in nuisances damaging to public health or comfort or pollution of a public water supply. The act required proof of such insanitary conditions as might be caused by discharge of "sewage or other wastes" into the receiving waters. Findings and orders of the director of health were made subject to approval of the public health council after full hearing. Penalty for failure to obey an order might result in a $500 fine.

"Ammendments to this act 1249–1261 G.C. were made in 1921 (water sections); in 1936 (legal procedures); and in 1945 (a finding and an order becomes prima facie evidence in a lawsuit for damages on account of water pollution). Constitutionality of the act has been upheld many times and many orders for pollution correction have been issued to municipalities and to industries in specific cases.

"A test case in the Ohio Supreme Court in 1929 (State vs. Williams, Delphos) established the validity of a suit in mandamus commenced in the Supreme Court by the director of health to enforce the order as provided for in Sec. 1249–1261, incl. G.C. Subsequently on several occasions, notably in 1934 (State vs. City of Columbus), mandamus proceedings were instituted successfully in Ohio Supreme Court by the director of health to bring about compliance with orders issued pursuant to Sec. 1249–1261, Incl. G.C., and in lieu of invoking the penalty ($500) provided for in Sec. 1260 G.C.

"In 1925 the original law of 1893 reapproval of plans was supplemented by the enactment of three sections, 1240-1, 1240-2, 1240-3 G.C. These sections were specifically directed toward water pollution control and for the first time industrial wastes were mentioned as such. For example, Sec. 1240-1 relates exclusively to industrial waste disposal. It makes mandatory the approval of the department of health of disposal plans for all new works and changes to existing works whereby liquid industrial wastes are produced. The next section, 1240-2, gives the department general supervision over the operation of such industrial wastes treatment and disposal works including sewage disposal; submission of performance records and pertinent information may be required. The last section, 1240-3, imposed obligations upon the department to study the lakes and streams, determine uses of the waters, causes contributing to their pollution, practicability of preventing and correcting their pollution so as to prevent damage to public health and welfare. Also the department was authorized to adopt and enforce regulations relative to water pollution control.

"In 1949 the legislature added another section, 1240-4, re water pollution control. This section makes it unlawful for public bodies or corporations to continue to discharge from existing sewers untreated sewage or industrial wastes into the public waters of the state. Details of treatment works, including degree of treatment and time for completion of works, must be satisfactory to the director of health. The usual penalty clause of a $500 fine is provided; but there is also included the provision that 'proceedings for the enforcement of the provisions of this section shall be instituted in the name of the state by the attorney general whenever requested to do so by the director of health, in the county having jurisdiction or in the county of Franklin, as provided by law.'

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mark in history, with flows as low as 3000 second feet at Cincinnati. A wave of sickness hit the city, yet the water tested satisfactory. After considerable investigation by the United States Public Health Service it was decided the high concentration of organic waste in the river, caused by the low flows, was decomposing and forming toxic materials that were not being removed by the treatment being given the water. This condition again repeated itself during the drought of 1934.

"*Interstate Legislation.* Negotiations among the several states of the Ohio River Valley were undertaken in 1936 to 1938 relative to a uniform legislative control of water pollution. As a result there was proposed the Ohio River Valley Water Sanitation Compact. Ohio's legislature adopted the compact in 1939. Eventually the last of the eight states involved, Virginia, adopted the compact in the spring of 1948. This agreement was effective June 30, 1948.

"Article I of the compact states in part—'Each of the signatory states * * * agrees to enact any necessary legislation to enable each such state to place and maintain the waters of said basin in a satisfactory sanitary condition * * * .' It was for the purpose of complying with the terms of the interstate agreement that Sec. 1240-4 G.C. was enacted by the Ohio legislature in 1949.

"One of the provisions of the compact, Article VI, stipulates that all sewage discharged into Ohio River or its tributaries must be treated; the minimum degree of treatment as specified is that ordinarily accomplished by efficient sedimentation and is defined as the removal of settable solids and 45% of the suspended solids. A greater degree of treatment may be required by the commission. Another provision in Article VI stipulates that all industrial wastes likewise tributary to the Ohio River system must be treated: the degree of treatment is not specified technically but is described '* * * to such degree as may be determined to be necessary by the Commission * * *.' In this connection it is interesting to note the wording of the inductory paragraph of Article VI which reads as follows; 'It is recognized by the signatory states that no single standard for treatment of sewage or industrial wastes is applicable in all parts of the district due to such variable factors as size, flow, location, character, self-purification, and usage of waters within the district. The guiding principle of this compact shall be that pollution by sewage or industrial wastes originating within a signatory state shall not injuriously affect the various uses of the interstate waters as hereinbefore defined.'

"The commission is authorized to adopt rules, regulations and standards for administering the provisions of this article. In accordance with this authority the commission has enunciated the policy that responsibility for bringing about the objectives of water pollution control of the compact will rest primarily with those state agencies within each state already charged by law with the administering of water pollution control. In Ohio this means the department of health.

"*Federal Legislation.* For many years bills have been introduced in the federal congress proposing federal control of water pollution. Finally, on June 30, 1948, there became effective Public Law No. 845 entitled, 'To provide for water pollution control activities in the Public Health Service of the Federal Security Agency and in the Federal Works Agency and for other purposes.'

"In section one of this act the policy of Congress was declared to be (a) 'to recognize, preserve, and protect the primary responsibilities and rights of the States in controlling water pollution,' (b) 'to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment,' (c) 'to provide federal technical services to state and interstate agencies and to industries,' and (d) 'financial aid to state and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs.' Responsibilities of the program were placed with the surgeon general of the public health service and with the federal works administrator.

"Some of the provisions of this act are as follows: (1) A report is to be prepared by the surgeon general setting forth a comprehensive program of pollution abatement needs. (2) The surgeon general is instructed to encourage water pollution control activities by the states through uniform state laws, interstate compacts, cooperative activities, support and aid in technical research on industrial waste treatment. (3) State water pollution control agencies are eligible for grants-in-aid to assist in carrying out control activities. (4) Public bodies are eligible for grants covering not to exceed one-third of the cost of planning and loans covering not to exceed one-third of the cost of constructing remedial works. (5) An eleven man advisory board recommends policies and programs; board comprised of five ex-officio federal representatives and six ou side of federal employ to be appointed by the President, one of whom represents affected industry. (6) Under certain conditions action for abatement of pollution may be taken by the surgeon general (a) if interstate waters are involved, (b) if health or welfare is affected of the people downstream or adjacent states, and (c) if the state water pollution control agency requests or consents to the action."

After Mr. Waring's address Bruce McDill, In Charge of Stream Pollution Survey Work, answered a number of questions.

1. What criterion will be used in deciding the degree of waste treatment necessary? Will the criterion be the condition of the river at various points, and if so, by what tests will this be determined?

Water quality objectives will have to be fixed. These qualities will not be the same for all streams nor along the same stream. They will depend on the conditions of the stream at the point where the waste enters the river. Tests used to determine those objectives would vary with the characteristics of the waste. For oxygen consuming pollution tests such as dissolved oxygen, B.O.D., total, suspended and volatile solids, pH, etc., would be necessary.

2. What numerical values are likely to be selected as desirable as measured by these tests, and what are the reasons for selecting these values?

Numerical values are difficult to select for all streams. A tentative standard used by survey personnel is dissolved oxygen not less than 4 p.p.m., B.O.D. not more than 50 p.p.m. and pH 6.3 to 9.0.

3. If certain stretches of the river exceed the selected standard at all times, will those adding wastes above or within the stretch be required to reduce their wastes? In other words, will all components of an industry be required to reduce or only those on bad stretches of the river?

Treatment will vary to some extent. The degree of reduction will be greatest where the contamination is the greatest.

4. Will the degree of treatment required of the paper industry in the Miami Valley be applied industry-wide throughout the state, or will the treatment required in the Miami Valley be different from other river valleys?

The treatment will be different. The degree of reduction will vary from area to area depending on the concentration of the wastes and the condition of the stream.

5. Where a mill discharges to minor tributary at some distance from the main river, the effect of the wastes on the minor stream may be very bad but the effect on the main river may be negligible. How will such a situation be handled?

Generally a tributary will be a problem in itself. The possibility of affecting public health would necessitate the reduction of the waste to a point where it was satisfactory. In a case of this type it might be better to sewer to the larger stream.

6. Some mills discharge their wastes into municipal storm or sanitary sewers. Will such mills be required to reduce their wastes before the construction of sewage plants into which they may eventually discharge their wastes for treatment?

This would be a problem between the industry and the municipality if the waste was discharged into the city sewers. The municipality can accept or reject the waste or require such treatment as may be necessary to protect the process and the plant.

7. The paper industry of the Miami Valley comprises several distinct pulping, papermaking and converting processes, each with its own type of waste. Since the methods of treatment of each kind are different and in some cases unknown, will a distinction be made in the degree of reduction required according to the type of operation?

A state agency cannot set up effluent requirements of industrial waste. It would be necessary to take into consideration the dilution factor of the stream.

8. If a reduction in waste discharge is required, in what form will such reduction be stated?

Express the reduction of oxygen demanding material or as pounds suspended solids per day in the stream at peak load demand. It would be up to the industry as to what volume and what material is to be discharged. It would be essential that flow measurement devices be set up and routine tests be made to determine the concentration of the waste.

9. By what analytical determinations will the waste discharged be gaged?

For oxygen consuming wastes, such as would normally be discharged from a paper mill, B.O.D., total suspended solids, vola-

tile suspended solids, and total dissolved solids. In some cases a complete sanitary analysis would be used.

10. Where the waste includes inert mineral solids, such as clay or asbestos fiber, which are not pollutants in the ordinary sense, will a reduction be required?

It can be seen that a discharge, high in inert solids, could be injurious to other users of the water farther down stream. However, in removing oxygen consuming material the inert matter will also be removed.

11. Where the papermaking waste contains coloring matter, the polluting effect of which is negligible, but the visible effect large, what requirements are likely to be applied?

In cases of this type it is necessary to consider public sentiment. The discharge of a visible color to a stream could, and probably would, bring criticism from those who see or use the water. Meeting the requirements of reducing the waste would probably correct the color.

12. When the Ohio Department of Health has completed its survey of the Miami River, will a report be published and made available?

Yes, this report will be made available to those who desire it. With limited personnel it is difficult to say when the work will be ready for distribution.

13. If all suspended solids were removed would the effluent be acceptable?

In one paper board mill the 5 day B.O.D. of the waste was 273 p.p.m. while the filtered waste was 162 p.p.m. In a fine paper mill the 5 and 10 day B.O.D. were as follows:

	5 day B.O.D.	10 day B.O.D.
waste	200	304
after 2 hrs. settling	68.5	73.9
filtered waste	34.9	38.3

Possibly a well-clarified waste could be discharged to some streams but this would depend on the dilution factor and the load on the stream.

14. What treatments would you suggest to reduce B.O.D.?

A great deal can be done in the plant to reduce the volume and characteristics of the waste. For example, attention should be given to segregation. Some can be discharged as is and thus concentrating others.

15. What methods are there for reduction of dissolved B.O.D.?

Biological treatment would probably be necessary. Some of the dissolved B.O.D. may be coagulated and settled out.

Through the courtesy of the Ohio Department of Health the mobile laboratory was in Middletown for inspection. This unit is a complete laboratory on wheels and is equipped to make a complete analysis, both chemical and sanitary, of any type of waste. George Manos, Chemist in Charge of the Mobile Unit, and David Stewart, Assistant Chemist in Charge of the Mobile Unit were present to explain the various tests they were able to conduct and their significance in the interpretation of pollution reduction.

E. O. Knapp, *Recording Secretary*

Delaware Valley

The Delaware Valley Section met at the Engineers Club, Philadelphia, Pa. on November 30, 1949. August S. Erspamer, presided in the absence of J. P. Weidner, Chairman of the Section. Dr. Erspamer announced that the next meeting, to be held on January 26 is to be devoted to a discussion of "Sizing."

Edward J. Albert, Thwing-Albert Instrument Co., sponsor for the speaker of the evening introduced him as follows: "I am introducing an outstanding figure in the field of quality control. He graduated from the Worcester Polytechnic Institute in 1916. He was with the Bureau of Standards for several years before joining Johns-Manville as a rubber chemist. He is now Director of Quality Control for that company in New York. He is active in the Society of Testing Machinery, the American Chemical Society, and the American Society for Quality Control. The picture we are to see was made by the rank and file of Johns-Manville personnel, not professionals, under the direction of Simon Collier!"

In introductory remarks given before the showing of the motion picture on Modern Quality Control, Mr. Collier commented as follows:

"In going from a seller's market to a buyer's market, quality control is important. Sales must be made, not merely orders taken and a quality product is essential to continued sales.

"In understanding a statistical approach to quality control, it is essential that this term be defined. To us, quality control means the efforts that are part of a plan set by a company to insure that the quality of the goods being shipped to a customer meets established standards. It is essential that these standards be economically sound. Statistical control is used in conjunction with older methods of inspecting.

"In years previous to mass production methods, each man was his own inspector. His pride in his workmanship kept the quality up. Under mass production new tools have been developed which give the most production at the least cost of goods which meet set quality standards. These tools include the use of the principles of mechanical engineering, industrial engineering, incentive engineering, and quality control. Years ago the plant management spent about 75% of its time in the plant talking to personnel, educating them. A 10% figure for the amount of time spent in this way is not unusual today.

"Some years ago Dr. Shewhart's ideas were applied. We sent men to universities, conducted our own classes and soon had a group of people and a plan. But, production personnel had to be sold. Anybody in production is human, hates change because it means more work for him even though he knows that extra work now may save work later. It was realized that the selling job was needed in using Dr. Shewhart's methods. In older days data were gathered and conclusions were drawn which were educated guesses. The Shewhart method eliminates these guesses. This is not to say that perfect production is always possible, but that with known variables it can be determined what amount of variation can be expected and still result in the production of good work.

"Movies have been used many years by Johns-Manville. Sales departments had reported that the production department "Don't Give a Damn." This type of complaint is inevitable unless unlimited funds are available for production. It is uneconomically sound to produce perfect goods always. In order to promote better understanding movies were shown to sales departments and to customers. Errors in production were given a better follow-up as a result. Also movies were made in cooperation with the Training Division to be shown to factory personnel. In one case a sheet was being produced which ran about 25% defective. Movies were made showing all types of defects and demonstrating the faults which caused these defects. In a few weeks the rejects were brought down to less than 5%. Pride of workmanship was, thus, sold to factory personnel.

"In selling quality control methods, it is not sufficient to sell the ideas only to supervisors but they must be sold right down the line. We made an error in this connection which was very costly. An engineer was assigned to the job of establishing quality control methods, he failed to sell the production department on the methods, and it took three years to sell the ideas after he had been taken off the job. Assistance should be asked of all in doing the job and assistance should be offered only to interpret their own data. It is far better to go slowly and be right than to make a mistake. A mistake made with a production man is never forgotten.

"The movie was made under my direction (Mr. Colliers) and a staff of four. It was not intended that it be shown to anybody outside of the Johns-Manville Corp. However, some outside help was given, gratis, by Ralph Waring of the

American Society for Quality Control and it was shown at his request to meetings of his Society. Other requests followed such as that from your organization. We appreciate the interest you have shown in this film, and are only too happy to have this opportunity to present it to you."

The showing of the sound-technicolor movie, "Modern Quality Control," was followed by those present with great interest. Attendance at the dinner and meeting was over 80.

A discussion period followed with Mr. Albert as Moderator. Several members and guests gave their views in addition to the questions given to and answered by Mr. Collier.

Question: At the start of a program of quality control, is it necessary to increase the inspection staff and to re-educate all concerned?

Mr. Collier: An increase may be necessary but not an enormous increase. Start slowly. An example at Johns-Manville was in connection with the manufacture of Jewett rings where before institution of quality control 8% were found to be defective. Analysis of tests indicated that 5% would be more normal. This figure was reduced shortly to 2% and currently is about 1/2%. In this case the production department made the improvements when the quality control tool was used.

Starting slowly, there will be a cost increase in production which is gradually offset by savings. If it does not pay off in cost reduction, there must be a decision made as to whether it should be continued. The methods are "tools" and if used properly may be made to pay dividends.

Ralph Knoll, Scott Paper Co.: A hand on the forehead will tell if a person has a fever, but a clinical thermometer will tell how much fever. This tool is similar to the thermometer as an advance over previous methods.

H. W. Stuart, Director of Quality Control, United States Pipe & Foundry Co., Burlington, N. J.: This is the fourth time that I have seen the picture and I brought four of our men who hadn't seen it. Starting slowly is important in successful use of the methods.

Question: Is statistical control such as this used in clerical operations as billing, etc.?

Mr. Collier: Johns-Manville is not using it for this purpose. Others have used it. The Aldens mail order house of Chicago is one.

Question: (H. C. Brill, duPont Pigment Div.) Is the method used in connection with chemical determinations? I was thinking particularly of a system such as paper, stock, ash.

Mr. Collier: Wuerdeman of Eastman Kodak used it in analytical work in the laboratory. The analytical plotting of sigma and probable error points on curves is used to good advantage.

Question: How does the use of a standard deviation curve compare with the use of the full curve?

Mr. Collier: Use standard deviation, range, or average curves in the control chart depending on circumstances. Range depends on actual data. These methods are short cuts over the mathematical methods by use of formulas.

Methods of mass production make the work become boresome. Control charts stimulate the thinking of workmen. There is a tendency to underestimate the potential of the average workman. Control charts take out the drudgery and stimulate production, thereby. Under a program of quality control, production becomes a competitive battle and has a psychological value. Application is simple and may require no more than about three hours per day for a clerk to gather and plot the data. In starting a program, pick that which offers the most fruitful promise first. Such items as consistency and freeness control at the head box are too complicated to start. They may have inherent variables difficult to bring under control. Waste savings are very easily sold to management.

Mr. Knoll: In the last three or four years at Scott Paper, we have used the same approach. A running chart for each unit is kept. Data was collected for a year before setting the bogey. We have used two sigma deviation points rather than the standard three sigma points. This gives a red light before the danger point is reached.

Mr. Collier: Two sigma limits and even $1^1/_2$ sigma limits are used successfully for signal points where processes are easily controlled.

Mr. Stuart: The principles apply and can be used for every process. Plot up the data.

Mr. Collier: The finding of "Not in Control" is quite common. If found, there is nothing the method can do until sources of variation are traced down and corrected to bring the process into control.

Question: All variables leading up to a process show their effects in the process. In a case where there are many raw materials, even as high as fifty, how many should be checked?

Mr. Collier: Run as many controls as necessary. In the case of raw materials, go to the vendor with the data. If no complaints are registered, the vendor willl make little effort to deliver within the required limits. If the vendor cannot do better, you should check to see if the variables are actually excessive, and if so, there is no alternative but to replace the source.

We had an experience with a certain gasket which was made in quantity for a customer. A delivery was found to be outside of specified imits. Investigation showed that in order to meet these specifications, much expenditure would be required. Inasmuch as the customer had used the under specification lot, he was asked to try to use more gaskets made with the cheaper method. Data was plotted and the customer was approached with information on the expected tolerances possible with this method and was asked to check to see if his specified limits weren't too severe. A mutually satisfactory arrangement was worked out. Cooperation between vendor and customer built confidence.

Mr. Schenk: What can be done if "Out of Control?"

Mr. Collier: An example is that of the shingle manufacture shown in the movie. By use of the testing instrument and quality control wide variations were brought down within control. The data from the production process itself was used to set the possible limits.

A. L. M. Bixler, Riegel Paper Corp.: The use of this tool is just begun at Riegel. It is a very fine picture.

Edward Albert, Thwing-Albert Instrument Co.: Over 30,000 viewers have seen it. Mr. Collier is National Secretary of the Quality Control Society and may wish to tell us something about it.

Mr. Collier: The American Society for Quality Control has 39 local sections. It has over 3000 members and was organized about three years ago. Previously there had been a few groups from which the society grew. Usually, meetings are held once a month. Training courses are run. Membership fees include a subscription to the bimonthly magazine. We believe in quality control and invite others engaged in this work to become members of the society.

A rising vote of thanks was given Mr. Collier and the meeting adjourned.

Kalamazoo Valley

The Kalamazoo Valley Section met at the Columbia Hotel, Kalamazoo, Mich., on December 1, 1949. H. A. Lips of the paper dyestuff laboratory of E. I. duPont deNemours, Inc., Wilmington, Del., discussed "Shade and Quality Control in the Dyeing of Paper."

On January 12 the 15th Annual Paper Makers Get-Together was held at the Hotel Harris. These annual affairs are sponsored jointly by the Kalamazoo Valley Section and the Michigan Division of the Superintendents Association. R. A. Hayward, President of the Kalamazoo Vegetable Parchment Co. presided as toastmaster. The feature speaker was J. T. Wilson, Chief Physicist, Allis-Chalmers Mfg. Co., Milwaukee, Wis., who talked on "Atomic Power and Its Significance to America."

Maine-New Hampshire and New England

The Maine-New Hampshire and New England Sections will hold a jointly sponsored meeting on June 22–24, 1950, at the Wentworth-by-the-Sea, Portsmouth, N. H. Norman I. Bearse of the Champion-International Co., Lawrence, Mass., has been appointed chairman of the technical program. Jack Fife Wright of the National Aniline Division, A. C. & D. Corp., Boston, Mass., will be chairman of the arrangements committee.

Empire State

Northern New York Group

The Northern New York group of the Empire State Section met at the Hotel Woodruff, Watertown, N. Y. on December 8. J. H. Heuer, the chairman of the group, presided. Frank Hoar of the J. D. Jenssen Co. introduced the speaker, Jess H. Davis, President of Clarkson College of Technology, Potsdam, N. Y. and outlined the background of experience which had fitted him to handle authoritatively the subject "Trends in Engineering Education."

Western New York Group

The regular monthly meeting of the Western New York Group took place Wednesday, December 14, at the Prospect House in Niagara Falls, N. Y. Approximately 50 members and guests attended the excellent meeting presided over by Irving V. Earle, of the Upson Co., Lockport, N. Y.

Speakers Group, Western New York Group TAPPI Empire State Section Meeting, Dec. 14, 1949. L to R—B. J. Stanselow, Moore Business Forms, J. T. Coghill, Speaker, The Curlator Co., Gordon Storin, Niagara Alkali Co., and Irving V. Earle, Upson Co.

B. J. Staneslow, Moore Business Forms, and chairman of the Program Committee introduced the guest speaker, James T. Coghill, Vice-President of the Curlator Corp., Rochester, N. Y. who spoke on "The Development of the Curlator Process." Mr. Coghill said, in part:

"The development of the Curlator itself goes back about five years and the preliminary laboratory work six years further. The original discovery that fibers could be curled was made in Kenogami, Quebec at Price Brothers Ltd. Mill. Under the direction of Dr. Hill, this laboratory discovery was carried on until it was necessary to build a commercial machine. At this time the Consolidated Machine Tool Corp., Rochester, N. Y., took over the designing of a suitable machine and later formed a subsidiary company, the Curlator Corp., to produce the curlator.

"It is easy to curl pulp fibers in a laboratory but the production of curlated pulp with a commercial machine has been difficult. Basically four operations are involved: first, taking pulp at 3% consistency and thickening to 10%; second, rolling the pulp fibers into clumps or nodules at 10–12% consistency; third, squeezing pulp to 20% consistency under pressure; and fourth, rubbing and rolling the pulp under pressure to curl the fibers.

"Curlated pulps have higher tear and lower mullen strength than untreated pulps. The curlated fibers have an increased elasticity or stretch and are softer and limper than noncurlated fibers. The porousness of curlated stock is much greater and curlated pulps are generally freer than untreated pulps.

"Four curlator machines have been built for Price Brothers and fifteen other curlators are on order." The maximum capacity of the curlator at present is about 40 tons of pulp per day.

Metropolitan Group

The Metropolitan Group of the Empire State Section met on November 14, 1949 at Fraunces Tavern in New York City. John Cornell, Co-Publisher of the Paper Mills News, gave the main address. His topic was "Economic Factors upon Which Trends in Industry are Forecast." Mr. Cornell's remarks follow:

"The ability to decide whether to expand or contract business operations is an important function of management. Building new plants at a time when a recession occurs may mean serious losses. On the other hand, standing pat just before a boom means missed profits—profits that go to the competitor who forecast wisely. Successful firms pay premium salaries to executives who can predict trends in industry.

"There are five main groups of economic factors which must be studied in order to forecast trends in industry.

"(1) The social frame of reference. This depends upon government regulation of business, trade union demands, action of pressure groups, state rights and regulations, functions of the national government including war-making power, employment and minimum wage regulations, subsidies and tariffs, and government spending when in the magnitude of $40 billion annually.

"(2) The pattern of business. This is determined by competition for raw materials and consumers in the many separate but related markets, supply and demand variables, top management policy patterns of business operation and market maneuvering, technological progress in production expansion, control of three important variables—cost, selling price and volume, sales research, and human relations.

"(3) Mass Psychology. This includes the impact of propaganda and emotional drives on the actions of groups and classes, patriotism and wartime cooperation, the urge for social security, pressure groups by racial, religious and economic classes, resistance to high prices, mass markets manipulated by advertising and selling the 'right' to a job and fear of unemployment.

"(4) Financial factors in the operation of business enterprise such as profit and loss, business climate, break even points as accelerators or brakes on business expansion.

"(5) Fiscal policies of the national government. These depend upon the vast national debt, currency and credit policies, balanced budgets vs. deficit financing, fiscal policies as a method of controlling the business cycle.

WILLIAM LANDES

Hudson Valley Group

At the meeting of the Hudson Valley Group held at South Glen Falls, N. Y. on November 11, 1949, William A. Stanier, Consultant for J. E. Rhoads & Sons, Wilmington, Del. gave the following talk:

Choosing the Correct Mechanical Power Transmission Method

WILLIAM STANIAR

MECHANICAL power transmission is one of the vital factors governing the economical and efficient operation of any industrial plant. In the operation of your particular plant there is nothing of greater importance than your mechanical power transmission, since without it there would be no operation. Equally important is the correct choice of method and equipment.

Industry has not always recognized the necessity of correct mechanical power method and the important part it plays in uninterrupted and economical production. Management has always been very particular about the selection of plant machinery because efficient machinery is a good investment, but in the past it almost completely ignored the equipment which was to furnish the power for that machinery. They failed to realize that with the drive right, power is applied to the machinery without interruption; with it wrong, power supply is distorted and production suffers. During the past few years, however, a change has occurred, and now management, due to the necessity of watching costs, has begun to appreciate the value of correct mechanical power application from a production and plant operating cost standpoint.

The selection of engineering equipment of any kind is frequently difficult because of a similarity of basic characteristics. This basic similarity prevails in the various methods used for transmitting power mechanically. This, in many instances, is the cause of incorrect selection.

The correct and economical solution of driving problems is dependent upon a realization that (1) Mechanical power transmission is a most important subject because of its necessity in most all

WILLIAM STANIAR, Consulting Engineer, Palm Beach, Fla.

industrial operations, (2) its primary requisites must be understood, and (3) unless the most adaptable equipment and methods are used for modern operating requirements, low efficiency, loss of production, and high-maintenance costs result.

The primary requisites are (1) Mechanical power transmission is a definite engineering subject and not simply an auxiliary, (2) it is composed of two general systems, (3) each system is composed of several methods, (4) each method is composed of a number of accessories, (5) each method of each system is adaptable for a definite purpose.

Modern operating requirements are, from a mechanical standpoint: (1) moderate and high velocity ratios, (2) step and infinite variation of speed, (3) high starting torque, (4) vibration and shock, (5) high efficiency—minimum power consumption, (6) overload release, (7) good lubrication, and (8) compactness.

From an atmospheric standpoint they are: (1) the mists and vapors of the corrosive acids, (2) abrasive dusts and (3) temperature and moisture. An understanding of these mechanical and atmospheric conditions assists in choosing the drive, since regardless of the conditions, mechanical power equipment is available to cope with each of them. This availability of suitable equipment, however, does not seem to prevent a continuation of maintenance, power, and shutdown losses. This is so because the economic value of correct mechanical power selection is frequently overlooked.

All industrial plants have an investment in mechanical power equipment. The larger the plant, the greater the investment. The magnitude of the investment for large industry and the monetary savings possible by the installation of correct equipment is usually not apparent to the executive and engineer.

As an example I cite a large industrial organization. Their investment in manufacturing equipment is approximately $350,000,000. Their investment in mechanical power equipment is conservatively 3%, which equals $10,500,000. The average life of correct mechanical power equipment is estimated at six years. Therefore the annual replacement cost is $1,750,000. Experience has proved that the average life of incorrect mechanical power equipment is four years. On this basis and for a similar investment the annual replacement cost is $2,625,000, an increase of $875,000 per year, and this is first cost only. These are large figures but nevertheless are true for all industry in direct proportion to the investment.

Mechanical power transmission can be separated into two general systems, the "flexible" and the "rigid." Each of these systems is composed of several methods and each method employs various accessories. The correct determination of system assists in the proper selection of method and, subsequently, minimizes breakdowns and reduces maintenance costs of the method accessories.

Breakdowns experienced in the accessories of the method applied are usually the effect and not the cause of the trouble. The selection of mechanical power method and equipment is most important to the user since it can result in either gain or loss from a production, maintenance, and power cost standpoint. Most all mechanical power difficulties can be traced to a lack of knowledge of the fundamental principles of this engineering subject. With the drive right, power costs are reasonable, production is maintained at a maximum, maintenance costs are low, and the plant superintendent and engineer can forget the drive. With the drive wrong, power costs are high, production is interrupted, maintenance costs are high, and management wants to know why the increase in cost per unit of production.

When choosing a transmission method it is necessary to decide which general system is adaptable for the character of the load and the equipment to be driven. Many experiences substantiate the fact that fundamentally the success or failure of any mechanical power installation depends to a large extent upon the general system chosen.

The "flexible" system is composed of the following methods: (1) modern group (belting or chain), (2) chain direct, (3) V-belt, (4) pivoted motor-base, and (5) flat-belt direct. All of these absorb vibration and reduce load impact.

The "rigid" system is composed of the following methods: (1) direct motor coupled, (2) gear reduction units, (3) motorized gear units, and (4) open gearing. All of these localize shock and vibration.

In view of a similarity of basic characteristics in methods of both the "flexible" and "rigid" systems, parallel situations can be simplified by these generalizations.

1. High-starting torque—injurious to any method unless relieved electrically or mechanically.
2. Power requirements—fundamental basis for decision between group drive and direct connection.
3. Intermittent or steady load—methods of the "flexible" system for intermittent loads; methods of the "rigid" system for steady and uniform loads.
4. Frequent starting and stopping—injurious to "rigid" system methods if starting torque is involved and the power high. Methods of the "flexible" system are safer.
5. Across-the-line start motors—methods of the "flexible" system are better for this kind of starting.

After determining the system the choice of the method should be governed by the adaptability of it to the drive requirements. From experience with all methods of both the "flexible" and "rigid" systems I have drawn these conclusions.

When deciding between "group driving" and "direct drive" these are your governing factors.

1. Power requirements—for individual machines above 10 hp., use direct drive.
2. Character of load—if high-starting torque exists, use direct drive with suitable equipment for overcoming its effects.
3. Arrangement of driven equipment—arrange in line or in parallel for group driving.
4. Atmospheric conditions—if severe, use direct drive.

Group driving is power economy since motorization is governed by the running instead of the starting loads of the driven equipment and therefore power factor is not adversely affected.

If you are considering the direct-chain drive, the choice is between the silent and finished steel roller types, depending upon speed, power requirements, and kind of load.

The advantages of chain drives are their flexibility, positive speed ratio, efficiency of 98.2%, their ratio capacity of 10 to 1 on short centers, their high speeds, long life, low maintenance, and center adjustment is unnecessary. However, they do have disadvantages which are: minute chatter, they can become noisy, oil leakage is possible, pitch elongation is possible, they are not good for high-starting torque from line-start motors, nor where slip is necessary.

If you are considering the V-belt drive, its advantages are that it is good for pulsating and shock loads, it is silent and chatterless, short or moderate centers are possible with ratios to 8 to 1, there is moderate maintenance and no oil to contend with. The disadvantages are that it must have center adjustment, its life is moderate and it is subject to atmospheric effects, it has an efficiency of 90 to 92%, it does not possess positive speed ratio, it is not good for high-starting torque with line-start motors, and centrifugal effect is possible.

The pivoted motor-base drive has certain unique advantages which are: automatic synchronization of belt tension to load, automatic accommodation of normal belt stretch, centrifugal tension, and load fluctuations, and a minimum of slip at peak loads. Its other good features are: efficiency of 96 to 98% if proper type leather belt is used; ratios of 7 to 1 on short centers; it will give long life with low maintenance, and it is shock absorbing. It, too, has its disadvantages. It is subject to atmospheric effects, it will not furnish positive speed ratio, it is not good for high starting torque with line-start motors and should not be used where slip is necessary. There is a small amount of motor vibration particularly if incorrectly installed.

I have been discussing "flexible" methods. What about methods of the "rigid" system?

The direct-coupled motor is real direct connection. It is usually integral motor mounting with the driven machine speed the same as the motor. If high-starting torque exists the motor must be of the correct type or a mechanical device must be used to overcome the effects.

The worm gear unit is adaptable for both vertical and horizontal driving. Its advantages are that it has ratio capacity to 10,000 to 1 in small space, it can accommodate high-input speeds under heavy loads, it transmits power at right angles and it is silent in operation.

The herringbone gear unit is available in single, double, and triple reductions with shafts in line or offset. Its advantages are the smooth action of its gears with no backlash, it possesses great general strength and capacity for heavy overhung loads.

The motorized gear unit combines motor and gear assembly in one unit with the gearing of either the helical or planetary types. Any type motor can be used. Its advantages are that no flexible coupling nor base plate is needed, it furnishes compact high-ratio direct connection, there is permanent alignment of motor and reduction gear assembly, and it is adaptable for vertical or horizontal driving. The motorized gear reducer however should not

be considered where the power requirements exceed 75 hp. and the ratio demands exceed 180 to 1 nor where ratio and power are high and where shock and high-starting torque exist.

The choosing of mechanical power equipment is to use one method in preference to another, whereas the application of such equipment is the appropriation of the various methods to a particular use. This distinction is important from an operation standpoint since there are times when seemingly a correct choice of method has been made but after installation operating conditions prove that the method is not exactly suitable for the conditions involved. These may be high-starting torque, low efficiency, high-power consumption, or severe atmospheric surroundings.

High-starting torque is one of the most destructive and troublesome factors in the application of mechanical power equipment to modern industrial requirements. Frequently, when choosing a driving method, this condition, if it exists, is either forgotten or not given thought. The results are expensive and a hindrance to continuous production.

All methods of both systems are subject to the destructive effects of high-starting torque particularly when the driving motor is line-start. Line-start motors are generally employed because of their comparative low-initial cost.

In recent years several electrical, mechanical, and hydraulic devices have been introduced for overcoming the effects of high-starting torque, and for the gradual acceleration of heavy inertia loads. The most recent electrical device, I believe, is the electronic drive which employs a.-c. motors equipped with electronically operated magnetic slip clutches. The units provide stepless speed variation and shockless applications of power.

From experience with many devices I found that a mechanical device known as the "Bethlehem slip-ring starter" when applied as a coupling between motor and driven equipment or as an integral part of a pulley, sheave, or sprocket, would positively overcome the effects of starting torque and would, in addition, gradually accelerate the speed of the driven equipment. This device is comparatively inexpensive and operates on the principle of centrifugal wrapping friction. It makes possible the satisfactory use of either gear reduction unit, chain, V-belt, or pivoted-motor-base drives for high-starting torque from line-start motors. Another frequent necessity is instantaneous overload release. The Bethlehem starter will disconnect the motor from the driven equipment the instant the load exceeds the predetermined torque capacity of the device. It acts much quicker than electric overload relays.

The efficiency of any driving method is the ratio of its power input to its power output. The difference in efficiency of the various driving methods is real money from a power cost standpoint. This factor is often overlooked when drive choice is being made. It comes to light, however, when management questions the plant superintendent or engineer on power costs. As an example I cite a case in a large New England paper mill. A hydropulper was driven by a V-belt drive from a 125-hp. motor, 24 hours per day, 300 days per year. The power cost is $0.30 per horsepower per day. $0.30 times 125 hp. equals $37.50 per day for one 125-hp. motor. For a year of 300 operating days the cost would be $11,250 for one 125-hp. motor. The difference in efficiency between a V-belt drive and a Rockwood Tannate drive is 6%, in favor of the Rockwood drive. Conservatively we will call it a 5% saving in power costs per year, which in this case is 5% of $11,250 or $562.50, the saving in power cost per year for this one drive.

From an application viewpoint, unsuspected deleterious atmospheric conditions can cause premature failure and high-maintenance costs of the driving method chosen, therefore when selecting or applying a drive conditions of this character should receive serious consideration.

The ability to choose the correct mechanical power system and method is valuable to a superintendent or plant engineer and subsequently to management since a large share of operating profit or loss depends upon the choice. Profits of an industrial plant are internal as well as external, therefore as long as the importance of the mechanical link in the power chain from source to application is ignored by executive and engineer it will continue to be a waster of power and money and a brake on production efficiency.

Discussion of Mr. Staniar's paper

Question: What is the basis for your life expectancy figures?
Answer: The life expectancy of four and six years is based on my experience in the 85 plants of the DuPont Company where a study was made over a period of four years. Differences of two years can be due to the use of correct or incorrect equipment. It is particularly true of belting and is a reasonable figure. Using V-belting where rigid methods should have been employed was about the same. Not 100% sure of these figures for the paper industry as conditions are different. Of course, incorrect application can result in a life of 30 days for belting.

Question: What is life expectancy of V-belts under normal conditions—normal atmospheric and steady application?

Answer: Six to eight years if properly belted. I have had V-belts wear out in six months when improperly applied. Sheaves seldom wear out.

Question: Do you not count V-belts replaceable?

Answer: Yes, it is easy to replace V-belts, but this is expensive. I have used Rockwood Tannate Drives operating 10 to 12 years with only occasional dressing of belt. V-belts do not give such life. A proper belt on a Rockwood drive gives long life.

Question: Is that "proper" belt a leather belt?

Answer: Yes.

Question: How would you compare leather belt vs. V-belt vs. chain drive?

Answer: A leather belt has higher efficiency than a V-belt.

Question: What is the relationship of slip between leather belts and V-belts?

Answer: This relationship is based on the coefficient of friction. The coefficient of friction of a mineral-retanned belt is much higher than that of an oak-tanned belt. There is less slip with the mineral-retanned belt than with the oak-tanned belt. With flat belts, a creep of about 1% is always present. With V-belts there is about 2% slip. With the V-belt better transmission is possible when the pull is on the bottom and when the belt is under proper tension. Any friction-surface rubber belt has a low coefficient of friction as compared with mineral-retanned leather. The coefficient of friction of Rhoads Tannate leather belt is 0.81; whereas that of a good grade of rubber belt is about 0.35. It stands to reason that the leather belt will pull more load than the rubber belt. The coefficient of friction is a fundamental of V-belt power transmission.

Question: Do you have any figures on the relative efficiency of cast-tooth and cut-tooth gears?

Answer: No. For the last 20 years cast-tooth gearing has practically become obsolete. I think any industry using cast-tooth gears is not up-to-date.

Question: Why not cast-tooth gears?

Answer: Cast-tooth gears are noisy and have considerable back lash.

Question: Why, despite efforts of Rhoads and other leather belt manufacturers are the rubber belts the ones used in the paper industry?

Answer: Paper mill engineers do not seem to realize that they are losing power when using a rubber belt in place of a good grade leather belt. This is based on the coefficient of friction. This is the fundamental basis of belting transmission economy and efficiency. You may say that rubber belting does not give you trouble. Have you ever put a tachometer on the driven shaft to determine how far below the predetermined speed it is running? You may want shaft to run 150 r.p.m. Put a tachometer on to see if it is running 150 r.p.m.

Question: Omitting consideration of rubber and leather belting, is it not also a fact that the V-belt is rapidly replacing leather belting?

Answer: The V-belt drive is a short center drive and at the present time, the Rockwood pivoted motor-base drive, using flat leather belting is its keenest competitor. I would not say that the V-belt is replacing flat leather for short center work.

Question: Most drives today are on short centers?

Answer: I would not say most. Do you know that the Rockwood belt drive is replacing V-belt drives, because with the V-belt tension control is manual. With the Rockwood belt drive, the tension is automatic. This is the reason why the Rockwood belt drive, with correct belt, lasts as long as it does.

Question: How would you use Rockwood drive on a 3-bearing motor job?

Answer: Rockwood drives are being used to transmit 400 hp. and over.

Question: Do you ever recommend the use of the V-belt drive?

Answer: I am not against the V-belt drive. It is a good drive for certain conditions but the Rockwood drive, or the chain drive

is better, the chain drive when you must have positive transmission and must have predetermined speed of driven shaft.

Question: Is there any place for a fluid drive?

Answer: I have used them several times. They are expensive. One type is for infinite variation of speed, while another type is used for the gradual acceleration of speed. There is always 2.5–3% slip.

Mr. Staniar: I am surprised there are no questions regarding the Bethlehem-slip-ring-starter. DuPont has 2500 in operation, 60% of them used for instant overload release. They are used on mixers where chemical action sets in and the mix thickens. Initially these mixers were direct connected through motor reducers, but the result is not very good. When thickening causes stoppage, the motor releases. The mixer stops and motor continues. There must be many places in the paper industry where trouble is experienced with high-starting torque when using line-start.

I cite a case where a 350 hp. synchronous motor at 400 r.p.m. was direct coupled to the pinion shaft of a ball mill. A 10-inch-herringbone pinion of 20-inch face meshed with a 15-foot diameter ring gear. At first a clutch was used but we had much trouble. The starting load was high. Finally a 500 hp. Bethlehem slip-ring-starter replaced the clutch. The mix was 40,000 lb. of balls and 20,000 lb. titanium oxide ore. It took seven seconds for the motor to come to 400 ft. per min. speed. Nothing happened until the motor comes to speed, then the mill gradually starts to move and 14 seconds later it is up to speed of 21 r.p.m. with no shock.

Question: How much space does this starter take?

Answer: If used between the motor and speed reducer, it does not take any more space than a flexible coupling. It also acts as a flexible coupling. I have not found any other mechanical starter that is as simple, works as perfectly and is as dependable as the Bethlehem slip-ring-starter. It consists of a spider that is keyed to the motor shaft and on the spider are fastened two circular bands of laminated steel and brake lining which contact the inside of the driven drum. The drum is keyed to the driven-equipment shaft. As the motor speeds up it throws these bands out centrifugally and gradually exerts its torque on the inside diameter of this drum and thus gradually starts the load. If the load jams, the bands release because the predetermined torque of the Bethlehem starter has been reached. While the bands are slipping, the torque produces heat. If the motor is not taken off the line for three or four minutes, a hot drum will result. This is the only disadvantage of the Bethlehem starter. In one case we installed a thermocouple against the top of drum with control to throw switch of motor in case of stall.

Question: Who manufactures the Bethlehem Starter?

Answer: It is a Bethlehem Steel Co. patent. The device was originally known as the snub starter. Bethlehem steel did not do much with it. It is now manufactured by Jos. P. Madden, 342 9th Ave. Bethlehem, Pa. Each starter is a custom job for your particular installation. When ordering, the maximum running load must be given.

Question: Are there any adjustments?

Answer: It can be manually adjusted by increasing or decreasing the number of laminations of the bands. The capacity can be increased or decreased 10% by this method. Based on centrifugal force, the heavier the bands the more power; the lighter the bands the less power. There is no slip unless the predetermined torque of the device is exceeded.

Question: How about wear due to friction on bands?

Answer: There is but slight wear on bands. The only wear is when the starter is coming up to speed. If a jam occurs in the driven equipment and the motor runs 2 or 3 minutes, the bands will burn. New bands can be easily installed. In the paper industry, I believe that the greatest advantage would be in overcoming high starting-torque resistance. In many places, by using this device the use of a slip ring motor can be eliminated. This device has three attributes: (1) gradual acceleration of heavy inertia loads; (2) motor capacity can be based on the running load instead of the starting load; (3) instant overload release.

Question: Is the initial cost warranted?

Answer: Yes, for the services stated.

Question: For small installations is the high initial cost of belting warranted?

Answer: Yes. Good belting always results in savings. Mechanical power transmission should be such that it furnishes economical and uninterrupted production regardless of initial cost. Production means a lot more than the initial cost of a belt or a gear. This is the trouble the mechanical power transmission equipment manufacturers are faced with. They are campaigning to make industry realize that mechanical power transmission is power and not just belting, chains, or gears.

Question: The use of belt, V-belt, chain on chipper drive?

Answer: I would not use direct connection nor the silent chain on chipper drives. I would use either Rockwood, V-belt, or long-center flat-belt drive.

Question: What about the V-belt flat drive?

Answer: It is good for low-power steady-load drives.

Question: There is a power surge on the motor when large diameter stick hits the chipper. What application is suggested?

Answer: A flat belt could be used. A chipper is constructed with a heavy fly-wheel which eliminates the worst shocks. However, none will take all the shock from the motor. The tension on a belt builds as power increases. Rockwood takes shock better than V-belts.

Question: What is relative cost of Bethlehem starter?

Answer: A Bethlehem starter 20 hp. as coupling costs about $190, whereas a Fast coupling costs about $175. There are two types of Bethlehem starters: (1) coupling, (2) integral part of pulley or sprocket.

Question: What is life of Bethlehem starter under normal conditions?

Answer: If the driven equipment does not jam and starting and stopping is not too frequent the Bethlehem starter will last indefinitely with low-maintenance required.

Question: How well does the coupling need to be aligned?

Answer: It needs about the same alignment as a flexible coupling.

On December 15, Walter S. Miller, Chief, Fuel and Lubrication Engineer, Gulf Oil Corp., Pittsburgh, Pa., talked on "Drier Bearing Lubrication with Particular Reference to Circulating Systems Encountered on Modern Paper Machines."

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

Alkaline Pulping Session—1949 Fall Meeting

The Alkaline Pulping Session held at the 1949 TAPPI Fall Meeting convened in the Blue Room, Multnomah Hotel, Portland, Ore., Thursday, Sept. 15, 1949, at 10:00 a.m.; H. C. Wall, Longview Fibre Co., presiding.

Mr. Wall: The first paper will be given by J. S. Martin, of the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis. His subject is, *Sulphate Pulping of Logging and Sawmill Wastes of Old Growth Douglas Fir and Certain Associated Species* (see page 534).

R. H. Stevens: I would like to ask Mr. Martin if he has any information as to how the decayed wood affects the properties of the black liquor?

Mr. Martin: I do not have information on that, but the density values of the black liquors appear to be similar to those for sound wood; the extractives were not very high. There didn't seem to be anything abnormal judging from our usual tests on the black liquor.

Paul S. Billington: I would like to ask Mr. Martin if any measurements were made on the wood in regard to the ratio of springwood and summerwood? I noticed when the bursting strength decreases that there is an increase of tear which might be caused by the fact that some of the woods had a higher summerwood content than the others.

Mr. Martin: There were no measurements made on the summerwood. In fact, the advanced decay was in such condition that there were some holes and even pockets so it would be very difficult to actually make a measurement on the material.

G. F. Alcorn: Was any differentiation made between sapwood and heartwood in the old-growth Douglas fir?

Mr. Martin: In the old-growth Douglas fir used all the decayed wood was from the heartwood sections of the logs. Decay forms and is present in the heartwood so we cut it out and tested it. The rim material remaining was lot 1-A, the second lot of sound material.

R. N. Hammond: Was all the decay this white spot rot or was there some associated decay of other types?

Mr. Martin: There was no associated decay that we could find. This type of decay is much different than a lot of other decay organisms where there is a real deterioration in the chemical properties of the wood. In those cases there are much lower yields and a very brashy pulp.

Mr. Wall: Mr. A. Suter, of Gaylord Container Corp., Bogalusa, La., will deliver the paper *Centrifugal Clarification of Sulphate Liquor*, by A. E. Reed and W. F. Gillespie (see page 529).

Mr. Stevens: Were the tests carried farther to determine what effect the clarified liquor had in the digester?

Mr. Suter: No, Mr. Stevens. At the time we thought that we were short on clarifiers, and the centrifugal equipment appeared to us to be so practical and compact that we were interested. But, after we had leveled out the flow of liquors to the causticizers and so forth we found that we had all the settling equipment needed, therefore, it was just an experiment.

Mr. Stevens: You mentioned the effect of the CaO; have you studied the effect of any of the other components of that sludge that affect the settling?

Mr. Suter: No, we have not.

Mr. Stevens: I would like to suggest that, in my personal opinion, much of the detrimental effect that is attributed to calcium compound in the white liquor may really be due to the iron compounds. About twenty-five years ago I had occasion when working with a consulting engineering firm, to study the effects in a mill using niter cake. They were troubled by customer sales resistance to a color that developed in their pulp. At the same time the customers complained the pulp was not developed to the proper strength. They asked me to look into it and I finally found this color was the result, apparently, of iron compounds in the liquor which I traced back to the niter cake they were using. As they were neutralizing the niter cake with soda ash before adding it to their black liquor the logical thing was to filter out the ferric hydroxide precipitate and then they no longer had the color. In studying the problem I made the simple sulphide of iron and sulphur, as identified, and then made some experimental cooks with synthetic liquor, iron-free, to which I added this compound, I obtained the same color and the same reduction in strength. I wondered if in your study the same thing had been taken into consideration?

Mr. Suter: No, Mr. Stevens.

Mr. Wall: Our third paper, *The Relation of Kraft Pulp Quality to Wood Properties of Douglas Fir*, by R. N. Hammond and Paul S. Billington, of Weyerhaeuser Timber Co. Research Laboratory, Longview, Wash., will be given by Mr. Billington (see page 563).

Mr. Hooker: Do you see any justification as the result of your test for segregation of woods?

Mr. Billington: Well, I think that would be advantageous if it were practical to handle it on a large scale. I don't know how well that would work out in mill practice in trying to segregate these woods and then keeping the chips separate and cooking them separate.

Mr. Hooker: That would be a tremendous problem but because of your interesting study, I wondered if you would recommend to the management a change in their existing practice?

Mr. Billington: No. The primary effect of the wood properties on pulp quality is in the springwood-summerwood relationship, and it would be totally impossible to segregate these fractions.

F. W. Flynn: I noticed that there were no recommendations for combinations to obtain different properties. Were the fractions cooked separately?

Mr. Billington: They were all cooked separately, and we didn't attempt to mix them. We have done other work on mixing woods and found that the properties of the pulp resulting from a mixture can be calculated from the properties of the individual types of wood cooked.

J. S. Martin: I noticed there is quite a reduction in tearing strength, especially in the old-growth wood. Is it a usual thing?

Mr. Billington: Yes. As a rule we find a large drop in tear and fold on bleaching but a very small drop in bursting strength.

Bleaching of Kraft Pulp—Round Table

Mr. Wall: Part of this program has been arranged as a round table discussion on *"Bleaching of Kraft Pulp,"* with J. V. Savage, of the Crown Zellerbach Corp., Camas, Wash. as the moderator. We will ask him to introduce his panel of experts.

Mr. Savage: We are indeed fortunate to have three outstanding gentlemen in the industry to take part in this round

table. I will start by introducing Al Cadigan who is in charge of the technical department of the St. Regis mill in Tacoma. The next member of the panel is Mace Harris Northwest Paper Co., Cloquet, Minn., and the last, the man who had charge of development of the processes that are now in effect at the Weyerhaeuser mills at Longview and Everett before he retired, Raymond Hatch.

I have asked Ray Hatch to start this discussion by giving us a little resume of the research and background leading up to kraft bleaching and an opinion of the future as he sees it.

Mr. Hatch: Before the introduction of commercial liquified chlorine, calcium hypochlorite, either in the form of a bleaching powder or solution of chlorine in lime or soda, was the main raw material for the chemical agent used for the bleaching of sulphite pulp. When kraft came onto the market the papermakers and pulp manufacturers wished to produce a bleached pulp from kraft which would possess the high physical qualities possessed by the unbleached product but unfortunately, when they attempted to bleach kraft pulp with hypochlorite alone they found that the resulting pulp had as poor or even poorer strength than sulphite pulp. That practically led to giving up the bleaching of kraft pulp entirely until the advent of chlorination.

It may be interesting to those who haven't followed the history of bleaching to note that the first attempt made to chlorinate an alkaline-cooked pulp was made back in 1854 when Watt and Burgess secured a United States patent for the bleaching of soda pulp first by chlorination, followed by washing, and then bleaching with hypochlorite. That was before sulphite pulp was being manufactured. The reason why that procedure was never followed was because of the difficulty of producing chlorine in those days, and the fact that even if chlorine was produced, regardless of a high cost, they had no equipment which would stand the corrosive action of the hydrochloric acid resulting from chlorination. Consequently, the efforts of Watt and Burgess were purely of academic interest until 1913 when a Frenchman by the name of deVains secured a patent for the bleaching of kraft pulp by chlorination, followed by hypochlorite bleach. Even then the process was not a success until liquid chlorine came onto the market in quantity and at a lower price.

The general practice is to chlorinate the unbleached pulp either in one, two, three, four, five or six steps, depending on the whim of the individual mill. These may be split up into intermediate washings, intermediate extractions with caustic soda and various and sundry other procedures. Usually chlorination is followed by a caustic extraction. In Europe the general practice is to chlorinate, usually to the maximum point, wash and extract with hot caustic, and then use a hypochlorite bleach under controlled conditions of pH. In this country there are several different methods. In some cases the chlorination is carried on in two steps: first, a chlorination, followed by a neutralization of some kind, with more chlorine added and more lime or caustic soda, and then a washing, caustic extraction, and hypochlorite bleach. In other cas s the pulp is chlorinated in one step and extracted with caustic soda the same as the European practice, and then one or more stages of hypochlorite bleaching completes the process. You heard Mr. Billington describe the method that is being used now at Weyerhaeuser where the pulp is first chlorinated to a maximum point, washed, neutralized, given a partial hypochlorite bleach under very carefully controlled pH conditions, after which it is extracted with caustic and given a final hypochlorite either in one or two stages.

All of these processes, under careful control, will yield a very satisfactory bleached kraft pulp possessing a relatively high physical strength, and we have at last accomplished what the original manufacturers attempted to do when they started out to bleach kraft pulp.

Now the question is, what is the future of the bleaching process? It is my opinion that one of the new products which have been used in Europe, chlorine dioxide or sodium chlorite, will find increasing use in the production of pulps of high brightness and high physical strength. All who have had experience with sodium chlorite or with chlorine dioxide, know that under proper conditions very little degradation occurs and it is possible to produce pulps of very high brightness with very, very little loss in physical strength. However, the present cost of chlorine dioxide and of sodium chlorite doesn't lend itself very well to the production of a cheap, bleached kraft pulp. The cost of the raw material is so high that it adds considerable in dollars per ton to the price of the bleached product. However, I think as time goes on the price of chlorine dioxide or sodium chlorite will eventually reach a point where at least an appreciable amount of it may be used as an adjunct in the production of a high, bright bleached kraft.

Mr. Savage: Thank you, Ray. Now, a question: "Is any trouble experienced in accurate chemical measurement at the various stages in a kraft bleach plant?

Mr. Harris: At Northwest we use gaseous chlorine in our chlorination stages and very carefully control the temperatures and pressures. By doing that and by passing the chlorine through rotameters we have no trouble controlling the amounts. Our tonnage rates are not high, they vary from 60 to 100 tons a day, but even at 60 tons when the feed rates are low the measurement is accurate. I am talking from an operator's point of view, probably not from a technical man's point of view. He might ask for a more accurate control in the laboratory when he is making his experiments but from an operation proposition in the mill, the three chemicals can be controlled with rotameters nicely.

We have a lot of trouble controlling the lime solution that we use in our lime neutralization We found that it could not be passed through a rotameter satisfactorily, so our solution for that problem has been to use the pH recorder and controller with very thorough mixing of the lime and pulp before it comes to the pH contact point. If our rate of tonnage is sufficiently high so that the valve is open wide enough, around 80, 90, or 100 pounds, we do have a very good operation. If the tonnage is low, or it drops down toward 60 tons, we find that the lime will drop out in the pipeline and plug up the valve and the line, and we do have considerable trouble. However, as far as I know, 90% of the mills produce above 60 tons of bleached kraft a day so they should not have any trouble with pH control.

Mr. Savage: Is Don Baker here? He has just returned from Sweden and I wonder what they are doing over there in the way of treating equipment?

D. H. Baker: They are using a rotameter, or proraters as they call them, in some of the mills. Other mills are using modified V-notch weirs. One rather interesting application was a type of orifice plate very much like the Canadian Standard freeness tester that was used for controlling the very small amount of caustic soda in the pH adjuster in one of the later stages of hypochlorite bleaching. By means of a measured flow through the orifice and a weighted arm on the cone they were able to overflow a constant quantity of caustic through the orifice. This is rather sensitive and particularly adaptable to pH control.

Further than that I don't believe they were doing anything different from what we are doing. The V-notch weir is usually a rather sloppy method; it is messy around the mill. A flow meter is much cleaner. They were using them on bleach liquors without too much trouble.

As to chlorine dioxide measurement, I do not know just how they are measuring their liquors. It is in the experimental stage. They were using a flow meter in one plant. In other cases I think they were trying to use a pump.

Mr. Savage: Thank you, Don. We have a question here I

would like to ask Mr. Cadigan: "Use of chlorination and lime neutralization, second stage. Presume that for certain kraft pulps chlorine lime neutralization caustic hypo will produce strong white pulps. Discuss how to control neutralization in stage No. 2 with lime so that uniformity of finished product can be assured."

Mr. Cadigan: I think that is the question I submitted. The reason for the question is that we are having difficulty in controlling our lime. We have been feeding it through a $1^1/_4$-inch valve plug cock and we are having a surging effect. First we are getting plenty of lime and at other times we are not getting enough. At the last shut down, we broke our inch and a quarter down into three lines hoping that we could keep two of the lines full open and control final addition on the third line. We don't know just how that is working out yet and I thought somebody here might have some comment.

Mr. Savage: Mr. Cadigan didn't really turn that one in but I knew that he was the only one who was using lime in that particular capacity here on the Coast, and I also knew that he was having trouble. I thought he might open the door for somebody else to talk.

Mr. Palmer: It might be solved by a recirculation of the delivery line back to the storage.

Mr. Cadigan: That is being done, circulation from storage to the headbox and back through the inch and a quarter line.

Comment: We do the same thing, but I suspect you will have trouble with that third valve because it tends to control a small flow and that is where we have our trouble. As long as the flow is large enough we don't have trouble. We are using, incidentally, a Hill valve instead of a plug cock on our pH apparatus. We did have plug cocks but they were not satisfactory.

Lee Hill: I have seen a recent drawing of a chemical distributor installation, where a flow splitter which passes a considerably greater quantity of the chemical than is desired in the final process, is used after an orifice. By adjusting the position of the splitter to give the fraction desired flow can be kept large enough so that it is under control.

Mr. Savage: Mr. Hatch is not in active work in the mills anymore so I would like to give him this. "Since the goal of bleaching is a definite G. E. brightness or color with the least loss of physical characteristics why do some paper manufacturers attempt to determine the G. E. brightness on the sheet of pulp as received and not on handsheets made up from the pulp, and thus greatly embarrass the pulp maker by reporting low G. E. when actually the G. E. may be somewhat higher than specifications?"

Mr. Hatch: That is a controversial subject because usually the customer takes a sheet of pulp out of the bale, runs a brightness on it, and then complains because the pulp isn't as bright as required by the specifications. However, TAPPI has a standard method for the determination of the brightness of pulp which involves the very careful preparation of a brightness sheet using distilled water. In my opinion that is the only fair way to determine the brightness of the pulp because frequently the outside of the pulp sheet, as received, may show some reversion in color, whereas the interior of the sheet is perfectly normal and will meet the specifications. The problem is to get the customer to agree in his testing work to use TAPPI Standard methods. I think that would be the answer.

Mr. Savage: You mentioned color reversion and we have a question on that: "Has anyone developed a method for determining the color reversion of a pulp and a manner of expressing such reversion that could be used as standard, or be universally understood?"

Svarre Hazelquist: I think Ray slipped out of the last one very easy. Remember that he said that TAPPI specifies a given method of running brightness tests, the producer saying that it wasn't right. The Institute sends a tab for standardization, but even within two mills you have a problem. Now the reason I am bringing that up is because it comes into your color reversion deal. I think it is easy to express color reversion. The recession we speak of is the original brightness minus the brightness of the sheet that is tested. You can express it as percentage or in points. You run the surface sheet and then run a handsheet on the brightness tester. This gives a variation which fairly well ties in with the length of time that pulp has been in shipment regardless of the way it is bleached. About the only way that we know of to check color recession, we have had quite a bit of experience on this, is to ask our customer to ship back, out of the center of the bale, pulp that we have originally checked. And if you are fortunate enough to obtain samples from shipments to a customer, covering two months, six months, and a year, you can determine the color recession of the pulp to that one customer. However, one of the customers reported a bigger recession than we thought was possible. We had samples for each day we ran. We went back to the laboratory, picked out a sample that had been there for two months, ran the color recession on it and found that the recession was normal. We asked the customer to return a sample of that same pulp shipment and he was right. In other words, for our normal recession at an 87 brightness, we found that over a period of four months it is apt to go down to an 85 or $85^1/_2$. We found that the customer actually had an 84 brightness. So I don't believe you can set up a definite color recession standard. It has to be developed on a pulp after it has been shipped. In hot weather, there is more drying out of the sheet which results in more color on the surface. Unless you do as Ray suggested, run TAPPI handsheets; you will never get pulp stabilized as to color, and it has to be the customer's value. It can't be a sample that you store in your own warehouse under normal good conditions; it has to be one that goes through the same conditions as that sent to your customer.

Mr. Savage: Has any notable difficulty been experienced with sizing or other papermaking treatment of bleached pulp?

Mr. Harris: I can give you our experience. I wasn't aware that it appears to be rather universally accepted that high bleached krafts are difficult to size. We have been bleaching kraft at Cloquet since about 1935 and we used to use a two-stage system of bleaching to about 65 or 67 brightness. That pulp would size very nicely. Then we put in our new bleach plant with a four-stage system and caustic extraction, and the papermaker couldn't size pulp anymore. We buy our size from Hercules Powder Co. so we submitted samples to them both two-stage pulp and four-stage pulp, as they have some chemical system of evaluating the sizing qualities of a particular pulp. They found that the four-stage pulp was difficult to size which is quite important because, in our particular case, it cost us over $1 a ton of paper for the additional size. That is beater sizing and if we do go to tub sizing, since much of our bond papers are tub sized, it will cost another 20 cents in the tub sizing. I think we should tell that to the papermakers so they don't jump on the pulp mills quite so hard all the time for something that apparently isn't our fault. We have no idea how to correct it and the question, I think, should be submitted to someone who can tell us how to offset the effect so that there isn't that extra expense in paper manufacturing.

Mr. Billington: Is there any difference in the sizing qualities of pulps made from Western species and on the Eastern or Southern species or some of the European species? We do know that the alpha-cellulose in western woods is a good deal higher than the alpha in any other species in this country and in Europe.

A. Suter: We have the same difficulty and I was wondering if somebody could help us. The brighter we bleach the more sizing we have to use.

Mr. Brown: I don't know whether we hold our tongue in our cheek in the proper way or what but with kraft made predominantly with jack pine at 79 to 80 we usually can size it more easily than we can sulphite pulp. We haven't had any experience with Western wood. We have used fair amounts of lodge pole pine and can find no difference in the sizing characteristics of the bleached kraft from lodge pole vs. jack pine.

Mr. Cadigan: Our paper makers have shown us that they experience the same difficulty with sizing bleached Eastern pulp and also the Swedish pulp, as compared with the unbleached. It seems to be more or less universal.

M. H. Vaughan: The higher bleached pulps might have different cellulose characteristics and, of course, the lignin content is a little bit lower. The question is whether the sizing mechanism is so hooked up to those characteristics that it gives that difference. It would be very interesting to know whether a very strong, highly bleached kraft would have better sizing characteristics than one that was known to be very much degraded.

Mr. Hatch: I think we have to recognize, that with Western woods, and particularly on Douglas fir, the kraft bleaching process, which involves relatively strong caustic extraction, removes a lot of material which contributes very much to the ease of sizing. In other words, our Western wood species are high in alpha-cellulose and, after caustic extraction and the various steps of bleaching, a large amount of the pentosan material has been removed. There may be more than one way to solve the problem. Some of the modern wax sizes in which a certain amount of wax is incorporated in the rosin size may be of some help. It may be of some help to add some type of mucilaginous material like raw mucilage or product of similar nature that will contribute toward a better job when a normal amount of rosin size is used. I appreciate the fact that it would probably increase the cost of sizing but it may not increase it anywhere near as much as would be necessary if you have to add a very large amount of rosin size to secure the same result.

Mr. Harris: Ray mentioned caustic extraction which, I take it from the men I have talked with since I have been out here in the West, is substantially heavier than we use. We use 1% caustic. Some of these mills out there tell me they use 3 or 4% of caustic. I am just wondering what effect 1% has in our case.

Mr. Hatch: I don't think you have anywhere near the difficulty in sizing lodge pole pine that you would have with Douglas fir. Lodge pole pine is an excellent source of high strength kraft pulp but is somewhat lower in alpha content than Douglas fir.

S. I. Aronovsky: I can't report on any operating results but in working with experimental pulps from straw, we use a mixture of sodium sulphite and soda ash for the extraction stage rather than caustic soda. We find that the pulps are bleached to a higher brightness for the same amount of chemical, and also with a lower loss yield, because, the hemicelluloses, pentosans particularly, are not extracted quite so much by sodium sulphite as they are by caustic. Actually, of course, what we are doing is the old Cross and Bevan method of chlorinating and extraction with sodium sulphite.

Question: What does that do to the cost?

Mr. Aronovsky: The sulphite wouldn't cost any more than caustic. Soda ash certainly wouldn't cost as much.

Question: Do you use the same amounts?

Mr. Aronovsky: Actually, in our experimental work we use $^1/_2$% sodium sulphite as such, and $^1/_2$% soda ash as such. In all our figures that we have published we use chemicals as such because there are too many ways of figuring, such as whether it is on the caustic basis, the Na_2O basis, or the soda ash basis. Therefore, our figures actually mean we are using less soda in 1% total than we are in 1% caustic.

Mr. Savage: We all are faced with producing a pulp as cheaply as possible, and the first thing we do is see how low we can hold the pH in the hypochlorite stage and also how much residual chlorine we need to wash out at the end, or the minimum that we can leave in and still get by. When we have sizing troubles we immediately begin to wonder if we have gone too far in saving a penny on chemicals. Would anyone like to talk about the relative merits of high residual and short retention time or a low residual and long retention time in the hypochlorite stage?

Mr. Cadigan: I am assuming under those conditions someone must bleach to a certain color and does not have the capacity. Of course, we all want to bleach just like we want to cook, at the lowest possible temperature and the lowest chemical concentration. I think if I were up against a proposition like that I'd up the chemical or temperature, and raise the pH to give sufficient buffering to protect the cellulose during that type of bleaching. I think that would probably give the maximum physical characteristics.

Mr. Savage: In our case at Camas, we have plenty of retention time but by keeping the pH, say, at 8.5 and the residual down to perhaps as low as 5 pounds per ton of pulp, we can bleach and do a good job, but we do have sizing trouble. If we should raise the pH up to 9 that would retard the bleaching action, but we would get probably a little bit different character of pulp at a higher cost. Would there be enough improvement in the paper to pay for the higher cost?

Mr. Savage: I'd better read this question: "How best to determine the amount of hypo required; what should the pH of the final stock be; should an excess of chlorine be used with a higher pH and shorter retention time, the time and pH being the controlled variables, or should the exact hypo be added and the time ample to exhaust same? Discuss the effect and operating possibilities of each alternate.

Mr. Hatch: Would you express your own conclusions?

Mr. Savage: Well, I was wondering if the economical way is the minimum residual at the end of the retention time with a pH of 8.5 at the end of the retention time. We think that is the minimum pH that we should allow. By going to a higher pH and a higher residual chlorine at drop would the paper mill notice any benefits, or would we just lose money using the added chemical?

Mr. Hatch: May I say that I think that largely depends on the mill. An integrated mill can get away with things that a market mill cannot. A market mill has to produce pulp that will satisfy the customer as far as brightness and strength is concerned and it may have to put more money into the bleaching of that pulp to get a satisfactory brightness with satisfactory physical qualities. In an integrated mill the pulp goes directly from the bleach plant to the paper mill, and frequently it's possible to change the conditions or lower the cost without seriously affecting the results of the paper mill. I think that, in general, integrated mills are able to get away with a little lower brightness and with perhaps a little lower physical strength than the mill which is producing pulp for the market.

Mr. Harris: Ray, we have an integrated mill and of course, it takes us a shorter time to have complaints from the papermaker than it does those who are selling pulp. But, after all, we do have to maintain a quality. We have to have a given brightness even though it is lower, and we don't want it to vary up or down too much. Also, our strength should be relatively constant. On this question of the amount of chemical to use, does the market mill, where they probably do need better control than we do, find that it is better to use excess chemicals and a higher pH to be sure to get uniform pulp?

Svarre Hazelquist: We have heard mentioned a higher brightness of kraft. I think that ties in with the excess chlorine. You are bleaching at, say, 76 or 77% G. E. brightness,

so there is no trouble at all getting rid of the excess chlorine. If you bleach to an 86 brightness you have to be careful. You can't go below 8.5 pH. With an 80 brightness you can go down.

Mr. Aronovsky: As the pH is increased it costs more in chemical, but as the pulp is more resistant to beating it is stronger. Yield does go down as you go up on pH which can go as high as 10.5. The yield might drop $1^1/_2$ or 2% on a pH of 8.5 up to 10.5, so you want to take that into consideration.

Mr. Savage: I expect the difference between 8.5 and 10.5 would add at least 50% to the necessary retention time, wouldn't it, to get the color?

Mr. Aronovsky: Yes, it would.

Comment: Don't you think that possibly there is some relationship between bleaching at a high pH and for a long period of time and refining. We might be refining too much for the grade of pulp produced. As Mr. Aronovsky just mentioned sodium sulphite and soda ash might be used rather than caustic soda as an extraction after chlorination, since caustic extraction, particularly here where we are using 3 and 4% caustic, might remove too many of the lower celluloses?

Mr. Hatch: Yes, I think so. The way it affects the strength is to stretch out the beating time. In other words, more power has to be put into that pulp in order to develop the strength.

Question: Well, don't you think we are also removing some of the materials which contribute to a great extent to the bursting strength.

Mr. Hatch: Well, I am more inclined to think that as you remove more of the pentosan you have to subject it to more physical treatment in order to get an equivalent in strength. The pentosans or hemicellulose present enable you to beat with much less power to a given strength.

Comment: But this question of using sulphite and soda ash is worth some investigation as a partial replacement for caustic extraction because with caustic extraction we are duplicating too closely the production of alpha pulp which the papermaker doesn't necessarily want.

Mr. Hatch: That's right. Of course, with the Douglas fir we start out with a very high alpha-cellulose content at the digester.

Comment: One of the problems we have with fir pulp is that we always have rather low bursting strength; very good tear but low bursting strength compared to northern spruce or pine.

Mr. Hatch: Yes, it has a lower bursting strength.

Comment: Possibly there is a chance for improvement by removing the extractives by some other method than a straight caustic extraction.

Mr. Hatch: That may be, except you may start out with unbleached pulp with a very high alpha content such as that from Douglas fir. There are some other western species that are lower in alpha-cellulose, and even some portions of Douglas fir, which will give a lower alpha-cellulose content and a higher burst. They seem to be tied in together and I think it is largely due to the presence of hemicellulose.

Mr. Aronovsky: I would like to point out that bursting strength, as we consider it, is a combination of hydration and fibrilation. You can reach it through either one or both ways. If you retain your hemicelluloses your hydration will be much easier; you don't have to fibrilate or cut your fiber so much and you will get better strength properties. Remove the hemicelluloses and you are getting closer to the alpha or the cotton-type pulps where you actually have to have fibrilation in order to get better strength properties. At the same time you cut your fibers some more.

Mr. Savage: Based on the experience of our Research Department, they are of the opinion that chlorine only renders a portion of the product soluble, and it is their opinion that it is necessary to give it either a caustic stage or a mild caustic treatment to complete the solubility of the chlorination products.

John Rue: I think your statement reporting your Research Department's conclusions are quite correct, that chlorination will not result in the complete solubility of the products that are formed in pulping. Some type of solvent has to be used, such as caustic or sodium sulphite, to render those products thoroughly soluble. If they don't all come out at the end of that stage, they may come out at the end of subsequent stages, if they are used.

Mr. Savage: "If these products are not washed out, and are left in the pulp, what effect will it have on the chemical usage in later stages?"

Brian Shera: You have to wash out the residual chlorine because if it goes into the caustic stage at a high temperature with residual hypochlorite, you have caustic at about 140, 150, or 160°F. which is harmful. I don't think it's too difficult to wash out.

Question: Has anybody any idea, roughly, the per cent that might be left in that would not be harmful? For instance, all of us are trying to make the best possible pulp we can and we find we leave as much as $^3/_4$ of 1% of chlorine residue in our pulp after the first wash. It seems high to me on the basis of what we do on our white liquor wash.

Question: Is that residue insoluble in water?

Comment: That I couldn't say; I don't know.

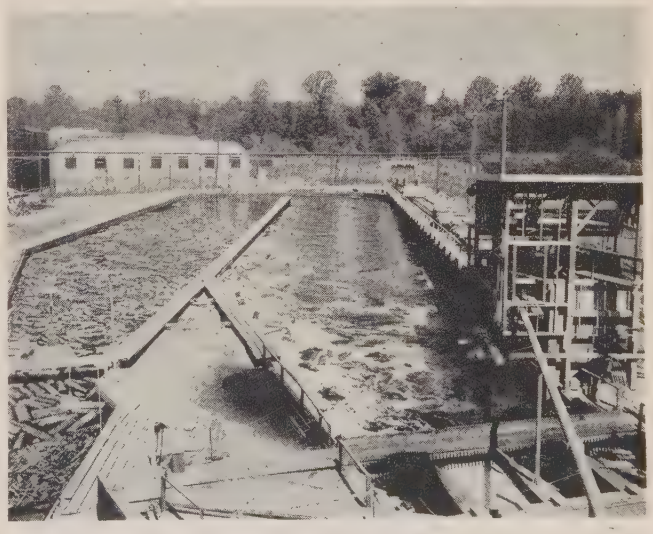
Mr. Shera: You definitely must wash out the free chlorine.

Mr. Aronovsky: I would like to point out another thing. This again has to do with experimental pulps which have a high hemicellulose content. We find that if we extract with sodium sulphite and carbonate we can wash the pulp much more easily than if we use caustic, because caustic tends to swell the fibers to a larger degree.

Comment: Those materials which you can wash out with water, either by a neutral or acid medium, are only chlorine, hydrochloric acid and soluble acids. Chlorinated lignin in kraft pulp is insoluble in water or acid, on which side pulp is, and so you have to wash with an alkaline medium.

Mr. Hatch: I might add that chlorinated kraft lignin is an unstable compound and if you chlorinate a kraft pulp, wash it thoroughly with water until that water is neutral, and allow that chlorinated kraft to stand for 1 or 2 hours, you will find it is strongly acid. In other words, the chlorinated lignin compound gradually breaks down and hydrochloric acid is formed. That is one reason why it is quite necessary to give your pulp a mild alkaline treatment in order to preserve it for future bleaching or extracting operations.

Mr. Wall: I wish to express my thanks to all the people who appeared on the program and my only regret is that we can't continue on longer.



Circulating "small log" pond at Longview Fibre Co. Mill

TALL OIL ABSTRACTS

With Particular Reference to Some End Uses

The following abstracts on tall oil literature was prepared by the National Southern Products Corp. (600 Fifth Ave., New York 20, N. Y.) for the benefit of chemists and operators in the coatings and allied industries.

Tall oil is a byproduct of the sulphate pulp industry. It is a mixture of fatty and rosin acids and is finding many new uses. The shortage of vegetable oil during the war led to intensive research both in manufacturing methods and applications. Several kraft mills, particularly in the South contribute the raw material either in the form of so-called skimmings or as more refined products. The heavy investment obvious in a refined tall oil plant would appear to indicate that the operators have a high degree of confidence in future markets. It is a field in which competent research and chemical engineering effort should pay dividends.

Paint

(1) Foulon, A. New adhesives and accessory materials in the paint and varnish industry. Farbe u. Lack 1934: 194, 206, 219–220.

Some new products, important to the paint and varnish industry, are discussed. Among the products discussed is sulphonated tall oil.

(2) Freitag, —. Importance of tall oil in the lacquer and iron industries. Oberflachentech. 15: 190–191 (1938); C. A. 33: 415.

From one ton of firwood comes about 30 kg. of tall oil. The oil contains impurities and fatty acids similar to those of linseed oil. The acids are esterfied with glycerol before they are used for making paints and lacquers.

(3) Grohn, Hans. Compositions used as coatings. German patent 526,491 (July 19, 1928); C. A. 25: 4725.

Esters of polyhydric alcohols or phenol are used with tall oil or liquid resin from the soda cellulose process. To produce coating compositions the esters are used in solution in benzine, with or without addition of driers, drying oils, or pigments.

(4) Heller, H. The fatty acids of tall oil with regard to chemistry and paint technology. Fette u. Seifen 44: 486 (1937); C. A. 32: 1121; T. S. 106: 305.

The advantages of the preparation of the glycerides of tall oil fatty acids in a stream of nitrogen and of the use of high-vacuum distillation for purification are given.

(5) Keghel, M. de. The utilization of tall oil. Rev. Chem. ind. 35: 170–173, 202–206 (June, July, 1926); Pulp Paper mag. Canada 26, no. 16: 529–531, 546, 548 (April 19, 1928); C. A. 21: 1354; T. S. 85–212.

The composition of a tall oil distillate is given. Listed are a number of uses of the distilled fatty acids, the resin fraction, and the alkali soap. Sulphonated resin acids can be used in ready-mixed, anti-rust and anti-fouling paints. The residual pitch, which is very similar to stearin pitch, can be used in the same kinds of paint as the sulphonated resin acids.

(6) Kolke, Fr. Use of phthalic acid-glycerol-tall oil resins in varnishes. Farben-Ztg. 42: 942 (1937); Zellstoff u. Papier 18: 34; C. A. 31: 8228.

In varnishes containing products made from tall oil acids, satisfactory resistance to weathering is obtained only when 4 parts of either fish oil, stand oil, or linseed oil stand oil are used with one part of an alkyd resin modified with tall oil acids. This fact resulted from exposure tests made with 12 varnishes.

(7) Kolke, Fr. Tall oil fatty acids in paints. Farben-Ztg. 41: 1186 (1936); C. A. 31: 3308; B. C. A. 1937B: 58; T. S. 106: 32.

The use of esterified tall oil fatty acids as a paint component is limited by their dark color, odor, and slow drying properties. Unsatisfactory elasticity and weather resistance of paint films restricts the use of excessive amounts of tall oil esters in paints.

(8) Kulikov, —. Drying oil made from tall oil. Byull. Lakokrasochnoi Prom. 1938, no. 12: 9–17; C. A. 34: 5682.

An investigation was made of the use of drying oils, made from a combination of tall oil neutralized with metallic oxides and from tall oil esterified together with rosin, in paints. The investigation showed that tall oil, when esterified or neutralized with metallic oxides with or without rosin, can be added to drying oil in amounts as great as 50%. Tall oil can be used in amounts of 25–30% in the production of paints from white pigments drying oils.

(9) Niesen, Herbert. Use of artificial resins utilizing tall oil fat acids in the paint and varnish field. Fargen-Chem. 11: 222–228 (1940); C. A. 35: 8326.

Glycerol, glycerogen, the monoethyl ether of glycerol or sorbitol were esterified with tall-oil fat acids together with either colophony, phthalic anhydride, maleic anhydride, or adipic acid to prepare a series of products; and these products tested as varnishes either alone, or in combination with chlorinated rubber, nitrocellulose, or drying oils. The products obtained from the fat acids condensed with glycerol and maleic anhydride or with monomethyl ether of glycerol and phthalic anhydride had the most promising weathering properties.

(10) Niesen, H. Tall oil fatty acids in paint technology. Fette u. Seifen 44: 426–432 (1937); C. A. 32: 1121; T. S. 106: 305.

It was found that paints made from the glycerides of tall oil dried more slowly with a film inferior to paints prepared from tall-oil fatty acid glycerides. However, the latter did not dry as well, and the dried films did not give off absorbed water as rapidly as did paints made with linseed oil.

(11) Pollak, Arthur. The utilization of tall oil in the paint industry. Oil and Soap. 17: 87–89 (1940); C. A. 34: 3492; B.I.P.C. 11: 32; B.C.P.A. 1940B: 544.

Listed are a number of industrial uses of tall oil and sulphonated tall oil. One of the uses listed is in the paint industry.

(12) Romanova, P. M., and Kotlyer, A. K. Tall oil in the lacquer and paint industry. Org. Chem. Ind. (U.S.S.R.) 6: 257–258 (1939); C. A. 34: 2620; B.C.P.A. 1939B: 859.

In the production of alkyd lacquers from tall oil and semi-drying oil excellent results were obtained. Lacquers and the resulting paints, which contained zinc oxide and lampblack, were superior to products from linseed oil.

(13) Schlenkert, H. Anticorrosive paints. Farbe. u. Lack 1938: 365–366. C. A. 32: 8800; B.C.P.A. 1938B: 1191; T. S. 109: 30.

Although they dry slowly, paints made from tall oil esterified with glycerol or pentaerythritol show good results in weathering tests. By using alkyds to replace in part the esters of tall oil, the slow drying can be corrected without affecting the properties of the dried film.

(14) Strauss, Robert. Tall oil in painting technology. Farben-Chem. 10: 389–390 (1939); C. A. 34: 3514; B.C.P.A. 1940B: 224.

Purified tall oil or its esters can be used in drying oils, and the esters used as a substitute for linseed oil.

(15) The use of tall-oil as a vehicle for corrosion-preventing paints. Farben-Ztg. 42: 1091 (1937); C. A. 32: 2376; T. S. 107: 149.

Tall oil alone may be used to prepare paints having good resistance to weathering, but the use of esterified tall oil with treated fish oil, linseed oil, or alkyd resin should produce a paint capable of resisting 3 to 4 years of exposure.

(16) Wolff, Hans. Tall oil for the lacquer industry. Farben-Ztg. 24: 580, 653–654 (1919); C. A. 13: 2289.

Tall oil, which is chemically allied to rosin, is used in dry-

ing agents and hardens to a brittle film. It is used as one of the constituents in certain paint products.

(17) Golden Gate Paint and Varnish Club. Use of tall oil in surface coatings. Paint, Oil Chem. Rev. 107, no. 22: 84–86 (1944); C. A. 39: 1303.

Two grades of tall oil were studied to determine characteristics derived from each in preparing varnishes. Oil H contained 60% fatty acids and 32.5% rosin acids, and oil L contained 47% fatty acids and 48% rosin acids. Varnishes were prepared by esterifying the tall oil with 10% glycerol, 11% glycerol, and 10 and 11% of tetrahydroxymethylmethane at a temperature of 550° F. for an acid number of 3 to 8. Tall oil H was treated with 8% lime by weight to prepare another varnish. Two-coat test panels were made of steel allowing 72 hours between coats. Open-vessel tall oil varnishes were very dark, but colors of Hellige 7 were obtained under an atmosphere of carbon dioxide in closed vessels. Lower viscosities were obtained and longer cooking times were necessary with the low fatty acid oil than with the high fatty acid oil.

(18) Hastings, R. Tall oil in the paint industry. Am. Paint J. 28, no. 3: 42, 46, 48, 50 (1943); C. A. 38: 267; B.C.P.A. 1944B II: 77.

A review of the applications of tall oil is given. The addition of driers to tall oil produces short, brittle films; liming, blowing, or esterification with polyhydric alcohols gives a product that can be used in a number of paint formulations. The metallic soaps of tall oil may be used as wetting agents and paint driers.

(19) Leuchte, Nachfl., Gustav. Use of tall oil acids in the preparation of paint materials. German patent 711,076 (Jan. 7, 1936).

Tall oil is mixed with a monovalent alcohol in the presence of a catalyst. Tall oil may be used alone or as mixtures with other fats or acids. With the product is mixed a metal or metallic oxide, such as lead oxide zinc dust, or calcium oxide.

(20) Niesen, H. Paints with a base prepared from esterified tall oil fatty acids. Farben-Chem. 11: 149–154 (1940); C. A. 37: 271.

Tall oil fatty acid glycerides, when worked up with wood oil and oiticica oil, exert a strong polymer-dispersing action. Stand oil varnishes have slow drying rates and good extensibility, but poor adhesive strength. Tall oil produces an embrittling effect, when worked up with alkyd resins. However, combinations with wood oil and linseed oil are suitable, when the digestion of the wood oil is carried out at a temperature of 280–290°C.

(21) Faucett, P. H. Oils and oil substitutes, Paint, Oil and Chem. Rev. 108, no. 11: 12, 14, 16, 18, 20, 22–23 (1945); Paint Tech. 11: 61.

Fatty acids of tall oil are isomerized with fuller's earth at a temperature of 585°F. then esterified with glycerol or polyglycerol to obtain improved oils. Driers may be added or the esterified tall oils heated with aluminum hydroxide, which reacts with fatty acids to form a gel, to improve their dark color.

(22) Golden Gate Paint and Varnish Production Club. Use of tall oil in surface coatings. Official Digest Federation Paint and Varnish Production Club, no. 251: 490–492 (1945); Paint Oil Chem. Rev. 108: 144–145 (1945); Am. Paint J. 30, no. 6B: 6 (1945); C. A. 40: 1324.

Work was carried out to make a substitute oil with a durability about the same as that of linseed oil. An attempt was also made to make an alkyd resin conforming to U. S. Navy specification 52R13. In both cases distilled tall oil was used. Two alkyd vehicles and two substitute oils were prepared. (The methods of preparation are given in the article). The two substitute oils, two blends of refined and kettle-bodied linseed oil, and a commercial tall oil glyceryl ester were compared as to durability. The five oils were used in the preparation of a white exterior oil paint, and the alkyd vehicles were used in a blue striping paint. Grinds were made in a ball mill, the same mill charge and grinding time being used in each case. The paints were brushed on steel exposure panels treated with dilute phosphoric acid, benzene, and water. Cares to be taken in the cooking procedure, the properties of each kind of paint, and comparisons between the different paints are discussed. From the tests made and results obtained there is an indication that tall oil vehicles favorably compare in durability with linseed oil or commercial alkyd resins.

(23) Heijmer, Gustaf B. Emulsions for use in paints and varnishes. U. S. patent 2,424,458 (July 22, 1947); C. A. 41: 6417.

A fraction of tall oil resins containing about 50% unsaponifiable oil-like matter and the balance chiefly fatty acids is comprised of a water-in-oil emulsion suitable for use as paints and varnishes.

(24) Hess, M. The uses of tall oil in the paint industry. Paint Technology 11, no. 128: 299–304 (Aug., 1946); C. A. 41: 3305.

A study of the terminology, methods of refining, neutralization, and separating the fatty and rosin acids was made. It was found that the drying properties of tall oil media is not always satisfactory unless they are with oils such as tung.

(25) Jarvelan Tehtaat O/Y. A tall oil product for making paints or varnishes. Norwegian patent 71,841 (March 24, 1947); C. A. 41: 6048.

Tall oil is esterified with fusel oils to reduce its acid number. The esterification takes place whether or not sulphuric acid and alumina is added; the product can be used for making paints and varnishes.

(26) Kirjakka, P. A binding agent for use in paints. Swedish patent 112,605 (Dec. 5, 1944); C. A. 40: 7658.

Liquid resin and a drying oil are heated to a temperature of 100–300° for a period of several hours.

(27) Kirjakka, P. A binding agent for use in paints and varnishes. Swedish patent 116,229 (April 16, 1946); addition to patent 112,605; C. A. 40: 7659.

Patent 112,605 is modified. In this process the mixture of liquid resin and drying oil is subjected to vacuum distillation before and/or after the heat treatment.

(28) Kirjakka, Pekka. Liquid rosin—a raw material for the paint industry. Suomen Kemistilehti 16A: 28–38 (1943); C. A. 40: 4894; B. A. 1947B, II: 295.

Liquid rosins, sulphate pitch, and crystal rosin were esterified with 10% of their weight by glycerol at a temperature of 200–250°, for a period of from 4 to 6 hours. In stainless steel equipment clear colorless esters were obtained from the liquid rosins and crystal rosin, but in iron kettles the esters were too dark to be used in light paints. Twice as much drier was required for paints prepared from the liquid rosin glyceryl esters as was required for linseed oil paints. For inside use, paints with 50% liquid rosin carriers and 50% linseed oil are suitable.

(29) Klint, Bernhardt & Co. Emulsions for paints and varnishes. British patent 575,448 (Feb. 19, 1946); C. A. 41: 5324; B. A. 1946B, II: 262.

A solution of tall oil resin, an alkyd resin, and a drying oil, with or without the presence of organic solvents, is used for the preparation of water-in-oil emulsions for painting, lacquering, or varnishing. The solution is emulsified, and pigments are incorporated for the manufacture of oil paints. Fatty acids of tall oil, esterfied with glycerol or pentaerythritol, may be used as the drying oil component of the emulsion. Compositions and methods of manufacture are included.

(30) Rooney, John F. Use of tall oil in Germany. FIAT final report No. 1144, June 5, 1947. 22 p.

The report covers the use of tall oil as a substitute for rosin and linseed oil in linoleum and surface coating industries and lists products manufactured by Spangenberg Werke Hamburg—Eidelstadt, Germany. Methods of preparing a substitute for linseed oil stand oil, to be used in the paint industry; tall Beckosol, a cheap resin used for wire coating and for gasoline tanks; and lumitol, to be used as a linseed oil substitute in enamels and varnishes; are given. Also given are various formulas for linoleum cements, and a gravimetric and volumetric method of analysis of tall oil for fatty acids, rosin acids and unsaponifiable matter.

(31) Annand, R. L. Liquid rosin in the paint and varnish industry. Oil Colour Trades J. 112: 1319–1320, 1322 (1947); C. A. 42: 1746.

A brief description is given of the Kraft process, and the characteristics of liquid rosin and some uses of its derivatives are listed.

(32) Bent, Franklin A., and Peterson, Elbert A. Reaction products of tall oil and allyl compounds. British patent 587,557 (April 29, 1947); C. A. 42: 2452.

Tall oil is treated with monomeric or polymeric allyl alcohol or allyl esters to yield resinous materials. The reaction is an ester interchange of the allyl polymer and the rosin and fatty acids in the tall oil. In the preparation of paints, the resins may be used alone or in combination with other resins.

(33) Kenmer, Henrich. Emulsion coatings. Farben, Lacke, Anstrichstoffe 1, 58–59 (1947); C. A. 42: 8489.

Paints can be made by the addition of tall oil or wax soaps, alkali ricinoleates, casein or starch, and up to 10% mineral oil to potassium or sodium-potassium silicates. The paints may be used on bricks, concrete, galvanized sheet, glass, mortar or sandstone.

(34) Kenmer, Heinrich. Tall oil in the coatings industry. Farben, Lacke, Anstrichstoffe 1, 20–21 (1947); C. A. 42: 8489.

Vacuum-distilled tall oil; treated with CaO or ZnO followed by esterification, incorporated into alkyd resins, or reacted with china wood or oiticia oil; gives a material suitable for use as coatings.

(35) Mann, Louise C. Use of tall oil in the paint industry. Am. Paint J. 33, no. 3, 66–67, 70, 72, 74, 78, 80, 82 (1948); C. A. 42: 9201.

A survey of the uses of tall oil in protective coatings is given. Although there are great possibilities for the use of tall oil in the paint industry, much research will be necessary to determine its place in paint formulation.

(36) Otte, N. C. Tall oil in paints. Farne og Lak, 1944, no. 19, 10–11; C. A. 42: 4749.

Tall oil stand oil, which is prepared by the esterification of refined tall oil with glycerol, may be used in paints.

(37) Itihara, Kentoro. Tall oil for paints. Science and Industry. (Japan) 15: 421–427 (1940).

A review which contains 27 references.

Varnishes

(1) Foehre, B. A drying composition for varnish. German patent 576,262 (July 3, 1931).

Crude tall oil is dehydrated with burnt sulphur, treated with about 8% sulphur chloride, and neutralized to produce a material for use as weather-resisting varnishes.

(2) Henkel und Cie G.m.b.H. Rosin esters. French patent 785,486 (Aug. 10, 1935); C. A. 30: 540.

Acid rosins or rosin acids are oxidized and esterified to make emollients or artificial resins, to be used in lacquers and varnishes. Mono- or polyvalent alcohols or their substitution products; glycerol, glycol, butyl alcohol, hexyl alcohol, phenol, or epichlorohydrin; are used to esterify the rosins or acids.

(3) Huebschner, Julius. Swedish liquid rosin. Seifensieder-Ztg. 48: 231–232 (1921); C. A. 15: 2177.

Descriptions of tall oil, tall oil distillate, and tall oil pitch are given. Tall oil pitch; a glassy, brittle mass with a melting point of 85°C., an acid number of 50.3, and a saponification number of 75.5; is used for cheap grades of black varnish.

(4) I. G. Farbenindustrie A.-G. Varnish, German patent 612.715 (July 15, 1931); B.C.A. 1933B: 76. Swedish patent 79,806 (July 4, 1932); British patent 383,233 (July 11, 1932).

Emulsifiers for drying oils and resins from wool fat is one of the uses of the unsaturated drying oils from tall oil.

(5) Ivanova, A. A. Tall oil as a source of drying oils. Byull. Obem. Opyt. Lakokrasochnoi Prom. 1939, no. 5: 18–20 C. A. 34: 6462.

Tall oil was esterified with glycerol in the following ways: 160 grams of oil and 40 grams of glycerol for 3 hours at a temperature of 270°C., and 180 grams of oil and 20 grams of glycerol for 3 hours at 250°C. An acid number of 6.8 was obtained when using 160 grams of oil; a value of 9.1 was obtained when using 180 grams of oil. With 10% drier no. 64, 40% white spirits, and 50% ester, the two esters dried after 72 hours.

(6) Ivanova, A. A. Drying oils from tall oil. Prom. Org. Chem. 7: 41–42 (1940); B.C.P.A. 1940B: 463.

A mixture of 58% tall oil, 28% colophony, and 14% glycerol was esterified, then oxidized at 150°C. in the presence of a metallic catalyst to obtain drying oils. A more elastic film may be obtained by the addition of dehydrated castor oil.

(7) Leuchte Nachf., G. Varnish from tall oil or tall-oil fatty acids. German patent 681,855 (Oct. 26, 1935); Auszuge 1940: P51.

Tall oil or its fatty acids are heated with about 5% glycerol and a small amount of an oxide of a polyvalent metal until the acid number is less than 50.

(8) Tall oil or liquid rosin. Svensk Poppersmasse-Tidn. 14: 550–552 (1937); Auszuge 1938: 67.

The average composition of tall oil is given, and some of its uses listed. Three fractions; fatty acids, a rosin fraction, and pitch; are obtained by vacuum distillation of tall oil. Tall oil pitch is used for varnishes, printing inks, and as a substitute for asphalt.

(9) Byproducts of the sulphate process. Finnish Paper and Timber J. 12, no. 16: 753 (Aug. 30, 1930).

A pitch-like substance, obtained from the distillation of liquid rosin, is used as the basis of a tall-oil varnish and in printing inks.

(10) Niesen, H. Tall oil for the varnish industry. Rdsch. tech. Arb. 17, no. 49: 3–4 (1937).

Although rosin-containing oil is not suitable, the fatty acid fraction is useful in the varnish industry.

(11) Obst, W. Utilization of tall oil. Seifensieder-Ztg. 60: 856 (1933).

The rosin and fatty acids of tall oil may be separated by distillation after esterification of the fatty acids with glycerol. Tall oil may be used in varnishes, cutting oils, plastic masses, emulsifying agents, and cutting oils.

(12) Reinert, Hans. Use of tall oil in varnish. Farbe u. Lack 1936: 461–462; C. A. 31: 5603; B.C.A. 1936B: 1054.

Esterified refined tall oil may be used as a substitute for linseed oil; esterified crude tall oil dries very slowly.

(13) Schmid, W. Possibilities for the use of liquid rosin. Papier-Fabr. 29, no. 1: 1–4 (Jan. 4, 1931); Farben-Chem. 2: 306–310 (1931); Papermaker 81, no. 3, suppl.: cni (March, 1931): T. S. 97: 279 C. A. 25: 3165, 5582; B.I.P.C. 1, no. 6: 12.

Liquid rosin; after purification with oxidizing agents, such as nitric acid, hydrogen peroxide, or chlorine; may be used in the manufacture of varnishes, printing inks, and waterproofing agents.

(14) Tengler, J. Rubber-containing varnish and adhesive. German patent 618,592 (April 5, 1932); Chem. Zentr. 1935, II: 3838.

An unsaturated compound such as tall oil is vulcanized with rubber. The resulting product is then dissolved in organic solvents and again vulcanized. A dilution agent is used to produce the final desired consistency.

(15) Uses of tall oil. Tech. Bull., Paper Makers' Assoc. Gt. Britain Ireland 13, no. 8: 109 (Aug., 1936); B.I.P.C. 7: 29; T. S. 103: 340.

A number of uses of tall oil are listed. A few of the uses include varnishes for outdoor use, asphaltic emulsions, hard and semihard soaps, and fruit tree sprays.

(16) Schade, Werner. A tall-oil varnish. German patent 705,939 (April 3, 1941); C. A. 36: 2170.

Tall oil is used in the preparation of a varnish by reducing the acid number of the oil to less than 60 with a primary amine. Lead, zinc, magnesium, or calcium oxide may be used to partly neutralize the oil.

(17) Alford, Edwin C. Tall oil and its uses in protective coatings. Paint Ind. Mag. 57: 94–96 (1942); Paint Varnish Production Mgr. 22: 87–88, 90, 92–93 (1942); Official Digest, Federation of Paint and Varnish Production Clubs, no. 213: 66–74 (Feb., 1942); C. A. 36: 2742; B.

Although it is difficult to obtain sufficiently high viscosity with tall oil in the varnish kettle for use as protective coating vehicles, esters of tall oil with glycerol can be heat polymerized to produce almost any viscosity. There is a possibility that tall oil will replace part of the drying oils in cheaper enamel products, flat grinding liquids, paint oils, primers, sealers, and undercoaters. Included in the article is the analysis of a tall oil and formulas for flat grinding liquids, films insoluble in hydrocarbons, floor varnish, floor enamel vehicle, a general purpose grinding oil, gloss oils, and mixing varnish.

(18) Burrel, Harry, and Vander Valk, Christy J. Polypentaerythritol varnishes. Paint, Oil Chem. Rev. 107, no. 25: 14–20, 33 (Dec. 14, 1944); C. A. 39: 1303.

Low-cost, rapid-drying varnishes of acceptable color, high

gloss, satisfactory water and alkali resistance and fair outdoor durability may be made from polypentaerythritol tall oil esters. Bleached tall oil, containing 40–55% resin acid, is reacted with 4.5–6% of maleic anhydride. By the time the mixture was heated to 250°C. the reaction was 98% complete. Esterification was conducted at 275°C., and sufficient polypentaerythritol was added to neutralize the acidity of both the tall oil and maleic anhydride. Equal parts of mineral spirits and turpentine were used to thin the mixture to 50% solids. The best conditions under which to carry out the reaction are in an inert atmosphere, with agitation, and with a high-boiling petroleum naptha to remove water for esterification. The best drier was a combination, based on varnish solids, of 0.50% calcium, 0.08% cobalt, and 0.02% manganese.

(19) Chatfield, H. W. Varnish constituents. New York, Interscience Publishers, 1944. 496 p.

The purification, production, uses, and esters of tall oil are some of the subjects covered in the book.

(20) Dorken, A.-G. The preparation of varnish from tall oil. German patent 722,247 (July 31, 1937).

To crude or distilled tall oil; which has been blown for 35–40 hours at 80–200°C.; then heated for 8–10 hours at 250–300°C.; is added polybasic acids or their anhydrides. The blown oil is then esterified with polyvalent alcohols or phenols or saturated with lime and siccatives and treated with organic solvents.

(21) Farber, Eduard. Resinous products for oilproof varnishes. U. S. Patent 2,312,807 (March 2, 1943); C. A. 37: 4832; B.C.P.A. 1944B, II: 331.

A mixture of one of the resin or fatty acids of tall oil and a cellulosic substance is heated to about 300°C. to produce a resinous material for use on ceramic materials or metals. The weight of acid used should be at least as great as that of the cellulosic substance.

(22) Farben, Eduard. Resinous products. British patent 546,384. (July 10, 1942); C. A. 37: 4162.

A resin is produced by heating polymerized carbohydrates with high-boiling wood acids, such as those contained in tall oil or wood resins. Because of the absence of reaction-inducing substances, the resin tends to have a higher dielectric strength and a higher electrical resistance than previously known resins.

(23) Mattiello, Joseph J. Paints, varnishes, lacquers, enamels, and plastics. Chem. Eng. News 23, no. 2: 136–143 (Jan. 25, 1945); Am. Ink Maker 23, no. 3: 33–34, 45 (March, 1945).

Tall oil, a waste product from the kraft paper process, contains some fatty acids of drying oils as well as rosin acids. Refined and improved tall oil can be used in place of the critical oils of a drying vehicle; tall oil, esterified with polyhydric alcohol, may be used as a modifying agent in alkyd.

(24) Oelwerke Noury & van der Lande G.m.b.H. Improvement of the varnish properties of drying and semidrying oils. Swiss patent 228,937 (Feb. 23, 1942).

One kg. of glycerol–esterified tall oil distillate is heated to 100–120°C. It is treated first with 3% of a castor oil-hydrogensulphide-polysulphide factice containing 20% sulfur, then with a stream of air under a vacuum of 3 mm. of mercury and with illumination of an electric glow discharge for 25 hours.

(25) Segessemann, Ernest. Production of low-cost drying oils from mixed esters. U. S. Patent 2,365,300 (Dec. 19, 1944).

The patent is primarily concerned with the production of low-cost drying oils or substitutes. All the hydroxyl groups of a polyhydric alcohol, except at least one which is esterified with a tall oil acid, are esterified with an unsaturated fatty acid. By the use of fatty acids of a higher degree of saturation than those used in the preparation of drying oils, products resembling tallow and like fats may be obtained. Examples of oils are included in the paper.

(26) Zhebrovskii, V. V., and Tsereshko, V. I. Use of tall oil for the production of alkyd resins. Byull. Obem. Opyt. Lakokrasochnoi Prom. 1939, no. 8: 19; C. A. 36: 6026.

Alkyd varnishes and enamels; prepared from unrefined tall oil distilled with super-heated steam in mixtures with cottonseed, linseed, and sunflower seed oils; dried at 20°C. and produced satisfactory films.

(27) Haines, Edward C. Oil-modified alkyd resins. U. S. patent 2,396,698 (March 19, 1946); C. A. 40: 3931.

A continuous process for the production of oil-modified alkyd resins is described. Aliquot proportions of an oil and a resin-forming component are added to a partially resinified reaction mixture of the two in preparing the resins. For example, one composition contains 720 pounds of tall oil, 160 pounds of glycerol, 120 pounds of maleic anhydride, and 40 pounds of water.

(28) Foulon, A. New adhesives and accessory materials in the paint and varnish industry. loc. cit., **Paints (1).**

(29) Grohn, Hans. Compositions used as coatings. loc. cit., **Paints (3).**

(30) Neisen, Herbert. Use of artificial resins utilizing tall-oil fat acids in the paint and varnish field. loc. cit., **Paints (9).**

(31) Heijmer, Gustaf B. Emulsions for use in paints and varnishes. loc. cit., **Paints (23).**

(32) Hess, M. The uses of tall oil in the paint industry. loc. cit., **Paints (24).**

(33) Jarvelan Tehtaat O/Y. A tall oil product for making paints and varnishes. loc. cit., **Paints (25).**

(34) Klint Bernardt & Co. Emulsions for paints and varnishes. loc. cit., **Paints (29).**

(35) Rooney, John F. Use of tall oil in Germany. loc. cit., **Paints (30).**

(36) Annand, R. L. Liquid rosin in the paint and varnish industry, loc. cit., **Paints (31).**

Lacquers

(1) Cellulose and lacquers. Wochbl. Papierfabr. 71, no. 2: 14–15 (Jan. 13, 1940); B.I.P.C. 10: 332.

A brief review is given of developments in lacquers prepared from cellulose acetate, nitrocellulose, rubber chloride, synthetic resins, tall oil, and train oil. Suitable applications of these lacquers are also mentioned.

(2) Heller, Hans. Use of refined tall oil in the lacquer industry. Chem.-Ztg. 63, no. 9: 77–78 (Feb. 1, 1939); B.I.P.C. 9: 367.

A typical composition and several methods of refining tall oil are given. Special consideration is given the continuous distillation method of Heller. Fatty acids of tall oil are used in the lacquer industry.

(3) I. G. Farbenindustrie A.-G. Tall oils in lacquers, adhesives, etc. German patent 517,902 (May 2, 1925).

Purified tall oil is one of the components of lacquer.

(4) Lacquer from tall oil. Wochbl. Papierfabr. 70, no. 20: 432 (May 20, 1939); B.I.P.C. 9: 525.

The fatty acids of vacuum-distilled tall oil, after esterification with glycerol or glycol, yield only products similar to linseed oil. Extensive application of these products are made in the German lacquer industry.

(5) The importance of tall oil as a raw material for the lacquer and iron industry. Nitrocellulose 9, no. 1: 9 (Jan., 1938); T. S. 107: 149.

The use of distilled tall oil as a substitute for linseed oil in the lacquer industry is mentioned.

(6) Bottcher, M. Use of tall oil for lacquer. Nitrocellulose 13, no. 5: 85–87; no. 6: 108–110 (May, June, 1942); Evensk Papperstidn. 45 no. 20: 433 (Oct. 31, 1942); B.I.P.C. 13: 251.

Crude tall oil is converted to coating agents by distillation with superheated steam. Tall oil, which contains a mixture of fatty and resin acids, is not suitable for use in lacquers to be treated with basic pigments. Stronger drying agents must be incorporated in lacquers made from tall oil than in those made from linseed oil.

(7) Freitag—. Importance of tall oil in the lacquer and iron industries. loc. cit., **Paints (2).**

(8) Henkel und Cie G.m.b.H. Rosin esters. loc. cit., **Varnishes (2).**

(9) Romanova, P. M., and Kotlyer, A. K. Tall oil in the lacquer and paint industry. loc. cit., **Paints (12).**

(10) Wolff, Hans. Tall oil for the lacquer industry. loc. cit., **Paints (16).**

Drying Oils

(1) Toernquist, J. G. A substitute for linseed oil. Swedish patent 45,817 (April 4, 1917).

Liquid rosin is one of the components of a substitute for linseed oil.

(2) Wallach, James A. Uses of fatty acids from pine wood. Soap 13, no. 3: 31–33, 73 (1937); C. A. 31: 3313; T. S. 106: 32.

The composition of crude and distilled tall oils is given. Distilled tall oil has many of the characteristics of unsaturated acids, and is often used as a substitute for semidrying oils.

(3) Allen, Austin O., et. al. **Linseed–oil substitutes. Official Digest Federation Paint & Varnish Production Clubs. No. 230: 396–404 (1943); C. A. 38: 1384.**

Tall oil pitch, tall oil-linseed varnish, vegetable oil pitch, marine pitch, limed rosin, petroleum drying oil, and processed rosin were studied as substitute materials for linseed oil. Tall oil pitch and marine pitch proved to be the most promising oil substitutes. In some cases, 50% of linseed oil is possible.

(4) Allen, Austin O., Parker, D. H., et. al. **Substitutes for linseed oil. Official Digest Federation Paint & Varnish Clubs No. 224: 78–81 (1943); Am. Paint J. 27, no. 23: 36, 38–39, 42 (1943); C. A. 37: 2593.**

Various film-forming materials; such as petroleum drying oil, pale asphalt, processed tar-oil pitch, and refined tall oil; were studied as substitute materials in exterior paints. The treated tall oil and processed pitch were used with best results; they may be used to replace about 25% of the linseed oil in exterior paints.

(5) Tall oil as a drying oil substitute. Am. Ink Maker 21, no. 4: 33 (April, 1943); B.I.P.C. 13: 379.

Tall oil is used in the preparation of driers, in the paint and varnish industries, and in the manufacture of certain types of printing inks.

(6) Svensson, O. Production of a drying product from tall oil. Swedish patent 104,969 (Feb. 15, 1940).

A product useful in the paint and varnish industry, is made by boiling tall oil with the lower aliphatic acids in the presence of a catalyst. Formic, acetic, or oxalic acids may be used; and lead or manganese compounds may be used as the catalyst.

(7) Tall oil. Am. Paint J. 27, no. 1: 61–62 (1942); B.C.P.A. 1943B, II: 84.

Tall oil, although it is not chemically equivalent to these materials, may be substituted for rosin and fatty acids.

(8) Widegren, Benkt. Tall oil—a substitute for linseed oil. Tek. Tid. 72, no. 37: 68–70 (1942); C. A. 38: 3858; B.I.P.C, 14: 102.

The author draws conclusions concerning the properties that tall oil, which is to be used in the lacquer and varnish industry and as a substitute for linseed oil, should possess. A coat of resin-free tall oil ester is fairly durable, but not as durable as one made with linseed oil. One of the disadvantages of the tall oil film is the low water resistance of the coat. A summary of the present knowledge of the composition and properties of tall oil is given.

(9) Aschan, Ossian. Occurrence and purification of pinabietic acid. Ann. 424, no. 2: 117–133 (1921); C. A. 15: 3095.

This article is a study of the rosin acid from Swedish tall oil.

(10) Bergstrom, H. O. V., Trobeck, K. G. and Heijmer G. B. The treatment of tall oil. Swedish patent 117,543 (Nov. 5, 1946); C. A. 41: 4648.

Oil obtained from the distillation of tall oil is heated, in less than 1% of a metal, to a temperature above 250°. The oil is heated until an acid number of about 7 is obtained, and the water formed during the reaction is removed. A drying oil is obtained which has an acid number of 7.1 and a Wijs number of 52.3.

(11) Ivanova, A. A. Tall oil as a source of drying oils. loc. cit., **Varnishes (5).**

(12) Ivanova, A. A. Drying oils from tall oil. loc. cit., **Varnishes (6).**

(13) Strauss, Robert. Tall oil in painting technology. loc. cit., **Paints (14).**

(14) The importance of tall oil as a raw material for the lacquer and iron industry. loc. cit., **Lacquers (5).**

(15) Alford, Edwin C. Tall oil and its uses in protective coatings. loc. cit., **Varnishes (17).**

(16) Segessemann, Ernest. Production of low-cost drying oils from mixed esters. loc. cit., **Varnishes (25).**

(17) Frydlender, J. H. The use of tall oil or liquid resin. Rev. prod. chim. 50, 6–9, 23–27 (1947); Chem Zentr. 1947, I, 477.

The article is a review of papers and patents on the manufacture, refining, properties and uses of tall oil and tall-oil acids.

Printing Ink

(1) Imperial Chemical Industries, Ltd., Horrobin, Sydney, and Stewart, Alexander. Printing inks. British patent 388,072 (Aug. 19, 1931); C. A. 27: 4698.

A water-in-oil emulsion may be prepared by incorporating water in a mineral oil. Tall oil is used as the emulsifying agent; the emulsion is suitable as a vehicle for printing inks.

(2) Kuehn, Walther. Use of tall oil ester in the printing industry. Farben–Ztg. 45: 404 (1940); Am. Ink Maker 19, no. 6: 27–29 (June, 1941); C. A. 35: 1250; B.I.P.C. II: 459.

Stand oils, prepared from three glyceryl tall oil esters and from linseed oil, were tested for drying power on metal foil and on various grades of paper. The tests were made after the addition of cobalt or lead-manganese naphthenates, Permanent red R and Mischweiss.

(3) Ludwigsen, M. Vegetable components in inks. Finnish patent 11,576 (Jan. 16, 1926).

Liquid rosin, sulphite waste liquor, or terpenes; after concentration to a definite water content; are mixed with unrefined glycerol.

(4) Tobias, Klaus. The use of tall oil as a binding agent for printing inks. Farben–Ztg. 45: 68–69, 86–87, 117–119, 133–134, 150, 167–168, 183 (1940); Am. Ink Maker 19, no. 6: 27–29 (June, 1941); C. A. 35: 1249; B.I.P.C. II: 459.

Drying tests were made in order to compare three tall oil glycerol esters, containing 12, 20 and 33% rosin, with an Argentine linseed oil. Tall oil glycol esters proved unsatisfactory, but tall oil glycerol esters of high rosin content were very satisfactory.

(5) Bernardi, Dominic J. Topographic printing ink. U. S. patent 2,348,594 (May 9, 1944); C. A. 39: 631.

A pigment is dispersed in sulphonated fatty material. Hydrogenated rosin or anhydrous sulfonated castor oil with tall oil may be used as the fatty material. Viscosity may be reduced by the addition of tall oil or diethylene glycol.

(6) Hezel, Erick. A siccative binder for printing inks. German patent 727,233 (Sept. 24, 1942); C. A. 37: 6479.

Tall oil is heated at a temperature of 330°C. in the presence of an inert gas. Natural or artificial resins may be added at 260°C., and 1–2% of magnesia is added when the oil has cooled to about 150°C.

(7) Bernardi, Dominic J., and Florence, Robert T. Lithographic printing ink. U. S. patent 2,406,795 (Sept. 3, 1946); C. A. 40: 7659.

A pentaerythritol ester of tall oil, used with a small quantity of another drying oil to make a vehicle for lithographic printing ink, is made by heating 91% of tall oil and 9% of pentaerythritol with 1% of lime in the presence of carbon dioxide.

(8) Bernardi, Dominic J., and Florence Robert T. Ve-

(8) Vehicle for printing ink. U. S. patent 2,416,676 (March 4, 1947); B.I.P.C. 17: 463; C. A. 41: 3639.

Vehicles for printing inks may be made by reacting tall oil, preferably mixed with a minor percentage of linseed oil, with lime. Data are given to show the effect of resin content. Formulations are given.

(9) Carman, Everett F., and Reil, Walther. Printing inks. U. S. patent 2,385,793 (Oct. 2, 1945); C. A. 40: 222.

A vehicle comprising an aqueous dispersion of a trialkylol amine soap of tall oil is used in the preparation of a news ink. Preferred compositions and formulations are given. The ink has desirable penetrating qualities and shows no strike through.

(10) Keghel, M. de. The utilization of tall oil. loc. cit., **Paints (5).**

(11) Tall oil or liquid rosin. loc. cit., **Varnishes (8).**

(12) Byproducts of the sulfate process. loc. cit., **Varnishes (9).**

(13) Schmid, W. Possibilities for the use of liquid rosin. loc. cit., **Varnishes (13).**

Artificial Resins

(1) Kirjakka, Pekka. Alkyd resins—a byproduct of the cellulose industry. Suomen Kemestilehti 13A: 62 (1940); C. A. 35: 2635; B.C.P.A. 1941B, II: 312.

Terephthalic acid, made by the oxidation of p-cymene with sodium dichromate and sulphuric acid, is heated with glycerol and tall oil for several hours at 200–250°C. to obtain an alkyd resin. The color varies from brown to yellow, and resins with different viscosities and solubilities may be obtained by variations in time, temperature, and in the amount of tall oil used.

(2) Farber, Eduard. The production of resin like substances. U. S. patent 2,343,215 (Feb. 29, 1944); C. A. 38: 5030.

A mixture of cellulosic plant material, from which pentosans have been removed and an equal weight of resin acids or mixtures of resin and fatty acids from tall oil is heated to a temperature of at least 300°C. to produce the resin like product.

(3) Farber, Eduard. Production of resinous products. Canadian patent 426,675 (April 10, 1945).

The resinous material is produced by heating a mixture of a cellulosic substance and at least one material from the group of resin acids of the kinds found in tall oil. The mixture is heated to at least 300°C., and this temperature maintained until resinification takes place. The resinous product is only slowly attacked by concentrated nitric acid, not wetted by water, stable and usually chemically inert. It is soluble in certain solvents and in chlorinated hydrocarbons, but is insoluble in sodium hydroxide solutions.

(4) I. G. Farbenindustrie A.–G. Artificial resins. British patent 355,281 (May 12, 1930); C. A. 26: 4139.

A soft resin is obtained by heating tall oil with maleic anhydride at 160°C., then esterifying the product with glycerol at 250°C. The soft resin is heated under vacuum to transform it into a rubber-like mass to be used in the manufacture of lacquers and oil varnishes.

(5) Farber, Eduard. Thermoplastic resins from cellulose and rosin acids U. S. patent 2,418,293 (April 1, 1947); B.I.P.C. 17: 537; C. A. 41: 4003.

A resinous material is obtained by heating one part of rosin, one-half part of tall oil, and one part of waste paper to a temperature of about 360°C. The resin may be modified by heating it with 0.2–2 parts of hexamethylenetetramine. The resulting product has a higher melting point and thermosetting properties.

(6) Henkel und Cie G.m.b.H. Rosin esters. loc. cit., **Varnishes (2).**

(7) Farber, Eduard. Resinous products for oilproof varnishes. loc. cit., **Varnishes (21).**

(8) Rice, Williams J. Tall-oil resins. U. S. patent 2,448,621 (Sept. 7, 1948); C. A. 42: 9204.

A hard resin is formed by heating tall oil, mixed with rosin or heated with lime to resinification, in the presence of 4–15% lime, at a temperature of 420–525°F. The resin may be blended with water, without an emulsifying agent, or diluted with organic solvents.

Alkyd Resins

(1) Kirjakka, Pekka. Production of alkyd resins from byproducts of the cellulose industry. Suomen Kemistilehti 13A: 62 (1940); C. A. 35: 2635; B.C.P.A. 1941B, II: 312.

Terephthalic acid, made by the oxidation of p-cymene with sodium dichromate and sulphuric acid, is heated with glycerol and tall oil for several hours at a temperature of 200–250°C. to obtain an alkyd resin. The color varies from brown to yellow, and resins with different viscosities and solubilities may be obtained by variations in time, temperature, and in the amount of tall oil used.

(2) Ruzacka, F. C. J. Alkyd resins. Oil Colour Trades J. 114, 442, 444, 446, 500, 502, 504, 556, 558, 615–616, 618 (1948); C. A. 42: 9201.

The article is a review covering alkyd resins for the past 10 years. Included is a summary of research which give interesting results for the surface coating field.

(3) Haines, Edward C. Oil-modified Alkyd resins. loc. cit., **Varnishes (27).**

(4) Drummond, A. A. Alkyd resins today. Chem. and Ind. 763–768 (1947); C. A. 42: 1081.

A general introduction to the alkyd resins.

Core Oil

(1) Hough, William J. Core oils. *U. S. patent 2,270,947 (Jan. 27, 1942); C. A. 36: 3141.

A polyhydric alcohol ester of an organic acid mixture, derived from the sulfate process of treatment of pinewood, is used in core oils. The organic mixture is composed of a major proportion of unsaturated fatty acids, a minor proportion of rosin acids, and a small proportion of sterols.

* This patent is owned by National Southern Products Corporation.

Linoleum Cement

(1) Bare, Martin K., and Stubblebine, Warren. Use of tall oil in linoleum cement. U. S. patent 2,439,377 (April 13, 1948); C. A. 42: 4770.

Ten per cent by weight of tall oil is combined with a siccative oil and a resin, then oxidized to form a gel characterized by toughness and resilience.

(2) Rooney, John F. Use of tall oil in Germany. loc. cit., **Paints (30).**

Treatment of Pigments

(1) Gage, Frederick, W. The treatment of pigments. U. S. patent 2,345,191 (March 28, 1944).

By addition of tall oil at an elevated temperature, the agglomeration of pigments during drying may be prevented. If it is added at a temperature above 50°C., a good product is obtained; addition below 50°C. gives an unsatisfactory product. An example is given.

(2) Gage, Federick W., and Gegner, Paul J. Preparation of pigments. U. S. patent 2,374,741 (May 1, 1945).

Precipitated calcium carbonate (finely divided) is suspended in an aqueous slurry with 0.5–2% by weight, based on dry calcium carbonate, of alkali metal hydroxide. It is then mixed with tall oil at a temperature above 50°C. The coated pigment is separated and dried at a temperature below 120°C.

Esters

(1) Tobias, Klaus. The use of tall oil as a binding agent for printing inks. loc. cit., **Printing ink (4).**

(2) Herbig, Haarhaus A.–G. Lackfabrik. Resinous condensation products. German patent 679,046 (Dec. 1, 1934).

The ester, resulting from the esterification of one mole of pentaerythritol with 2 moles of tall oil distillate until the acid number is about 2, is esterified with an ester from 2 moles of methyladipic acid and 2 moles of glycerol at 220°C. The resin

may be used in the preparation of pressed materials and as an impregnated agent.

(3) Widegren, Benkt. Tall oil esterified with pentaerythritol. Tek. Tid. 74: 153–158 (1944).

An investigation was made of the combination of pentaerythritol esters of tall oil with various contents of rosin acids, stand oil boiling, and blowing with air. The products were made into varnishes, with a modified phenol resin, to determine the importance of resin content of the esterified tall oil and the effect of preliminary treatments of the oil upon the properties of the varnish. High resin content tall oil gave better drying properties and less water resistance than low resin oils. Poor drying properties and low water resistance were obtained in products esterified with pentaerythritol alone. Varnish cooking gives an improvement in the water resistance in most cases; also the water resistance is improved by blowing with air.

(4) Wedegren, Benkt. Tall oil—a substitute for linseed oil. Tek. Tid., Kemi 72: 68–70 (1942).

The drying properties of tall oil are improved by esterification and stand oil cooking. The use of tall oil stand oil with artificial resins improves the water resistance; lower rosin content in tall oil decreases brittleness and improves the adhesive properties of the varnish.

(5) Burrel, Harry, and Vander Valk, Christy J. loc. cit., **Varnishes (18).**

(6) Golden Gate Paint and Varnish Club. Use of tall oil in surface coatings. loc. cit., **Paints (17).**

(7) Reppe, Walter, and Wolff, Werner. Vinyl ester. U. S. patent 2,228,365 (Jan. 14, 1941); C. A. 35: 3112.

A mixture suitable for use in lacquers is prepared by treating tall oil with acetylene at 170–225°C. A mixture is prepared by dissolving 3% of zinc oxide in tall oil, which has been freed from part of its resin content by distillation. After addition of an equal weight of toluene, the tall oil is heated with a mixture of two parts of nitrogen and one part of acetylene at 180–200°C. under a pressure of 15–20 atmospheres. The ester may be used in factice, floor covering, linoleum, cement, and putty.

(8) Reppe, Walter, and Wolff, Werner. Vinyl ester. German patent 722,465 (May 28, 1942); Swedish patent 98,482 (July 19, 1939); C. A. 37: 5078.

The mixture of unsaturated resin and fatty acids in tall oil is reacted with acetylene in the presence of zinc or cadmium salts of organic acids as catalysts.

Esterification

(1) Eck, Charles F., and Vilbrandt, Frank C. Development of the drying characteristics of tall oil by esterification. Virginia J. Sci. 2, no. 6: 201 (1941).

A study is made of esterification with polyhydroxy alcohols, the effect of the rosin content of tall oil, and the structure of the complex alcohol produced.

(2) Bent, Franklin A., and Peterson, Elbert A. Production of tall oil ester resins. U. S. patent 2,424,074 (July 15, 1947); B.I.P.C. 17: 744; C. A. 41: 6418.

The esterification of tall oil with polyhydric alcohols of aliphatic character produces resins having desirable film-forming properties. Some of the preferred alcohols are; allyl, methallyl, ethallyl, chorallyl, etc. Direct esterification of the alcohol with the acid, with or without solvent, is one method of forming the product; the acid exchange between tall oil and a polymer of an allyl-type ester is another. Some of the uses of the products are: as adhesives and interlayers for laminated articles; as self-sustaining films; and for sizing and impregnating cloth, felt, or paper.

(3) Faucett, P. H. Oils and oil substitutes. loc. cit., **Paints (21).**

(4) Hess, M. The uses of tall oil in the paint industry. loc. cit., **Paints (24).**

(5) Magnusson, K. H., and Richtet, S. U. K. A. Improvement of color, acid number, and drying properties of compounds containing organic acids having a plurality of double bonds in the carbon chain. Swedish patent 118,422 (March 26, 1947); C. A. 42: 338.

Compounds, which contain acids having a carbon chain with a plurality of double bonds (tall oil), are converted to esters of mono or polyhydric alcohol and treated with air or another gas containing oxygen, sulphur, selenium, or tellurium at a temperature of 200-300°. Oxidation or dehydration agent catalysts or catalysts preventing polymerization may also be present. Examples are given. In one example, tall oil acids were blown with air at 200° until the iodine number was decreased by half, then $NaHSO_4$ was added and the oil heated to 220-280°. Pentaerythritol was then used to esterify in the presence of HBO_3 and CO_2 or hydorgen at 250°. The oil was then blown with air at a temperature of 310°.

(6) Bent, Franklin A., and Peterson, Elbert A. The reaction products of tall oil and allyl compounds. British patent 587,557 (April 29, 1947); C. A. 42: 2452.

Resinous materials are obtained by treating tall oil, at a temperature of 150-300°, with monomeric or polymeric allyl alcohols or allyl esters. The reaction is an esterification or an ester exchange of the rosin and fatty acids in the tall oil with the allyl polymer. The product may be used alone or in combination with other resins in the preparation of paints.

(7) Cummings, Lowell O., and Vogel, Henry A. Solvent fractionation of tall oil. U. S. patent 2,444,730 (July 6, 1948); C. A. 42: 6536.

The first step in the separation of tall oil into its component parts is partial esterification with an open chain alcohol, which contains 1–5 carbon atoms, and a catalyst. It is only a partial esterification, the fatty acids are esterified, the rosin acids are not. Solvent separation, fractional distillation of solvent mixtures, and purification of the fractions by distillation follow the partial esterification.

Bibliography

(1) West, Clarence J. Tall Oil, Talloel, or Liquid Rosin—A by-product of the Alkaline Process. Appleton. Wisconsin Inst. Paper Chem. (1942).

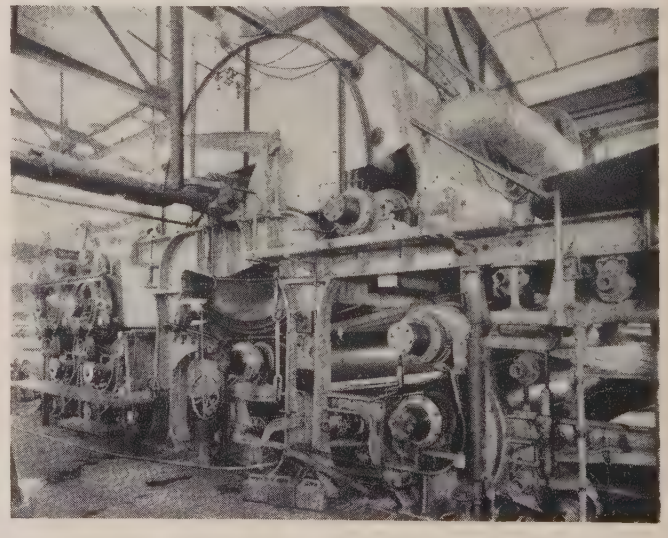
A bibliography with abstracts of 346 articles on tall oil. Of the 346 articles approximately 50 are concerned with paints, varnishes, and related industries.

(2) West, Clarence J. Tall Oil, Talloel, or Liquid Rosin—Supplement I. Appleton, Wis. Inst. Paper Chem. (Aug., 1945).

A total of 225 abstracts on tall oil. Approximately 35 deal with its use in paints, varnishes, etc.

(3) West, Clarence J. Tall Oil, Talloel, or Liquid Rosin—Supplement II. Appleton, Wis. Inst. Paper Chem. (Jan., 1948).

Supplement II contains 167 references, about 20 on paints, varnishes, etc. Contained in the three books is a total of 738 articles, patents, and reviews on tall oil.



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Fundamental Research Conference: Chateau Frontenac, Quebec, P. Q., May 29–30, 1950. Symposium: "The Papermaking Properties of Fibers." (Joint Meeting with Technical Section, Canadian Pulp and Paper Association).

Fifth Engineering Conference of the Pulp and Paper Industry. Netherland Plaza Hotel, Cincinnati, Ohio, October 2–5, 1950.

Technical Sectional, C.P.P.A., Mount Royal Hotel, Montreal, P. Q., January 25–27, 1950.

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April 13, 1950, Woodruff Hotel, Watertown, N. Y.

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March 23, 1950, Engineers Club, Philadelphia, Pa.
April 27, 1950, Engineers Club, Philadelphia, Pa.

OHIO SECTION:
February 9, 1950, Manchester Hotel, Middletown, Ohio
March 14, 1950, Manchester Hotel, Middletown, Ohio.
April 13, 1950, Manchester Hotel, Middletown, Ohio.
May 11, 1950, Manchester Hotel, Middletown, Ohio.

MAINE-NEW HAMPSHIRE SECTION:
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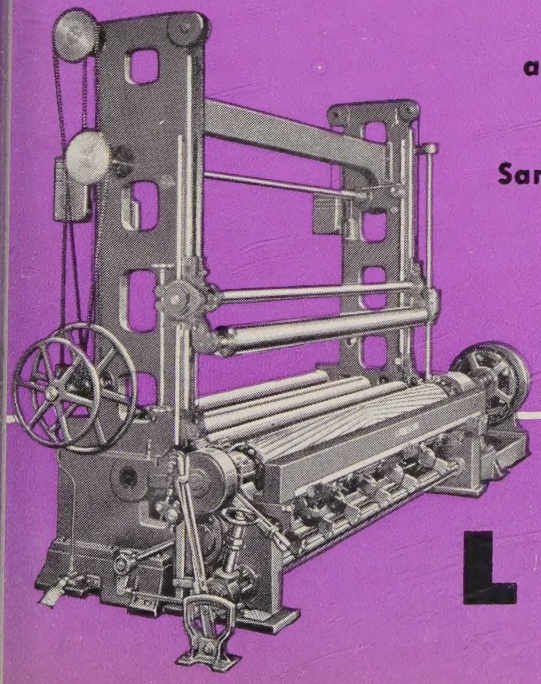

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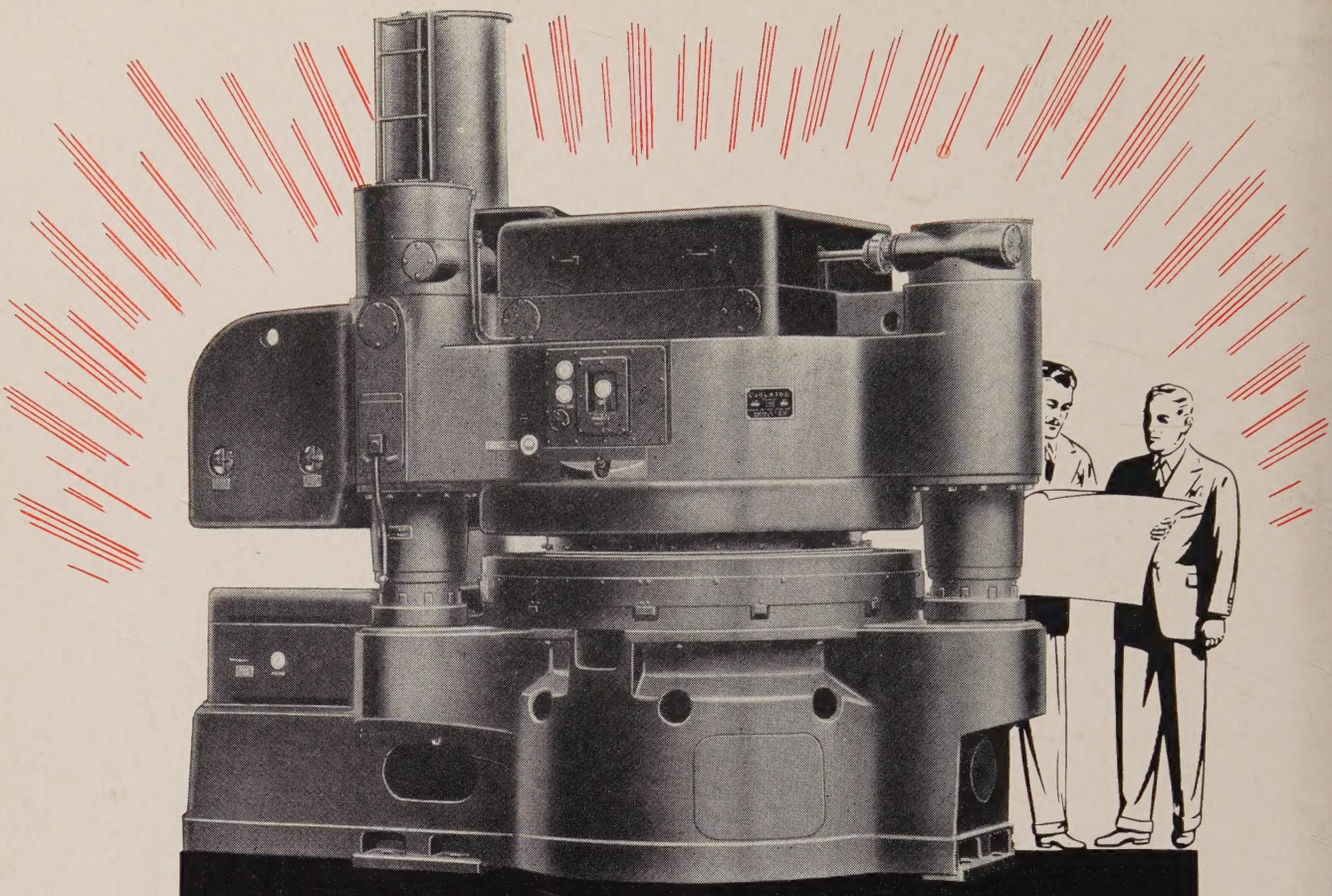

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